Route to:

Return to:

INSTITUTE OF GAS TECHNOLOGY

THE GAS INDUSTRY'S OWN EDUCATIONAL AND RESEARCH FACILITY

CHICAGO 16, ILLINOIS

GAS ABSTRACTS

JULY, 1959

VOLUME 15 NUMBER 7

AFFILIATED WITH

ILLINOIS INSTITUTE OF TECHNOLOGY

CONTENTS

1. **Management**—Gas industry progress, business problems, statistics, government regulation, safety, personnel, education.....213

2. **Energy Supply and Economics**—Resources, reserves, and competitive applications of the fossil fuels and other sources of energy, including nuclear and solar energy.....216

3. **Natural Gas and Petroleum Production**—Geology, exploration, drilling, well management, reservoir engineering.....218

4. **Gas Conditioning and LPG Recovery**—Condensate, dust, CO_2 and sulfur removal, dehydration, odorization, oil fogging, humidification; LPG recovery and refining.....221

5. **Natural Gas Transmission**—Pipelines, compressors, dispatching, flow regulation, communications, maintenance.....222

6. **Gas and LPG Storage**—Holders, pressure tanks, underground storage; liquefaction, refrigerated storage.....223

7. **Manufactured Gas and Chemical Processing**—Gasification of coal, oil; reformed gas; chemical treatment; byproducts; synthesis gas production and conversion; petrochemicals; catalysts, catalyst development.....224

8. **Gas Distribution**—City utility systems: design, operation, maintenance; weather influence on peak loads and supply; LPG-air mixtures.....228

9. **Gas Fuel Utilization and Appliances**—Domestic, commercial, industrial; burners; combustion research; air pollution.....229

10. **Equipment and Instrumentation**—Production and handling equipment, and maintenance; computers; controls; measurement.....230

11. **Materials of Construction, and Corrosion**—Metals, refractories, plastics; corrosion measurement, prevention.....232

12. **Analytical Methods and Tests**—Standard and research techniques for gas-making materials, products, processes; instrumental analysis.....234

13. **Basic Science**—Chemistry, physics and basic engineering related to gas technology; physical properties of gases: phase equilibria, thermodynamics, reaction kinetics, heat and mass transfer, fluid flow.....236

Services Available to Readers—Photocopies, microfilm, Russian translations, bibliographies and literature searches, *Gas Abstracts on Cards*, back numbers of *Gas Abstracts*.....**Inside Back Cover**

Publications Abstracted for Gas Abstracts.....**Back Cover**

O. P. BRYSCH, Editor

P. J. CHATTA, Assistant Editor

GAS ABSTRACTS is published and distributed monthly by the Institute of Gas Technology, Chicago 16, Illinois. The contents of selected papers and patents are reviewed impartially by the editorial staff and material of potential interest to the Gas Industry is presented. Subscription rates to non-members of the Institute: $18.00 per year to U.S. addresses; $22.00 foreign—Printed in the U.S.A.

Copyright 1959 by the Institute of Gas Technology.

A microfilm edition of Gas Abstracts can be supplied by University Microfilms, 313 N. First St., Ann Arbor, Michigan.

1. MANAGEMENT

Gas Industry Management

'Index' Shows New Gas Price Series. *A.G.A. Monthly 41,* 25 (1959) June (3 pp.)

Three significant revisions have been entered in the U.S. Department of Labor's "Wholesale Price Index." These revisions are the inclusion of the prices of non-utility gas sales, the inclusion of prices of liquefied petroleum gases at the production level, and the shift of the measurement of the average price of utility gas from the price to industrial customers to the price of transactions at the production point. The 1958 edition of the 'Index' is the first edition in which such information has been included.

The Lawyer as an Executive of a Regulated Utility Business. D. C. Power. *Public Util. Fortnightly 64,* 27 (1959) July 2 (8 pp.)

Lawyers may actually do better jobs than some others in a utility executive post because of the training to be objective and to see all sides of a problem. However, the law-trained mind has to undergo a difficult transition in order to master the human and public relations concepts that deal with serving and winning the good will of customers. Moreover, a lawyer must learn to use his imagination to blaze new trails of public service for his company.

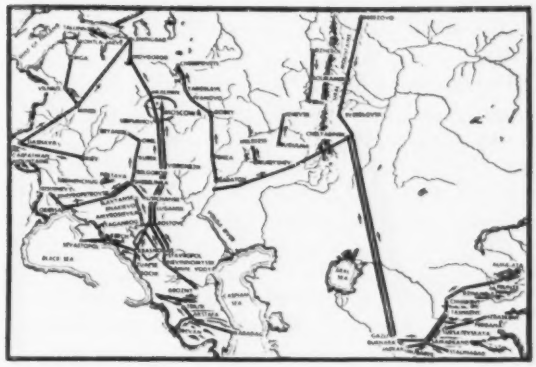
Gas Industry Expansion

Re-Examination of the Economics of Sizing Crude Lines. L. Cookenboo, Jr. and L. W. Smith. *Pipe Line Ind. 10,* 56 (1959) June (6 pp.)

Principal factors involved in cost minimization of pipelines are the cost of the line itself and the cost of the horsepower — plus a prediction of things to come. Where a choice lies between capital goods which are bought now and used for many years and labor which is purchased on a day-to-day basis over many years, it can be argued that the value of money spent now for capital goods should be considered in comparison with the present — not the future — value of labor which will be bought some years hence. The solution of such problems requires predictions of the economic life of the company, of future wage rates, of potential earnings from other projects to which the capital funds might be devoted as well as other considerations.

Examiner Approves Transwestern Line. *Oil Gas J. 57,* 70 (1959) July 6 (2 pp.); **West Coast Gas Faces New Fight.** *Petrol. Week 9,* 19 (1959) July 10 (2 pp.)

Russian Pipeline Projects for 1959-65



(From *Russia Revises Pipeline Goals.* See Abstract, p. 214)

Federal Power Commission examiner has approved Transwestern Pipeline Co.'s proposal to provide a new gas supply for expanding markets in Southern California, thereby overruling the FPC staff and California Public Utilities Commission which had objected to high gas prices set by Transwestern contracts. The ruling, subject to review by the commission, authorizes Transwestern to construct an 1809-mile pipeline from Texas to the Arizona-California border near Topock, Ariz. Cost of the project is estimated at $191,700,000. Pipeline will carry 300 MMCF/day of natural gas. FPC staff opposition to the examiner's recommendation is the principal complication. In the background, however, is the Supreme Court ruling in the CATC case, which urged price-conditioned contracts.

"From Wellhead to Burner Tip" . . . The Lone Star Gas Company Story. L. T. Potter, C. M. Hill, J. Kindle, J. C. Darrow and C. G. Barndt, *Gas Age 123,* 24 (1959) June 25 (22 pp.)

Special issue devoted to the Lone Star Gas Co. (Texas) on its fiftieth anniversary. A half-century of growth and development and of problems and difficulties has culminated in the industry represented today by Lone Star and its wholly-owned subsidiary, Lone Star Producing Co. Together, the two companies represent 1) operating properties costing nearly $400 million; 2) service to more than 800,000 customers; 3) service in an area measuring nearly 400 miles north to south and about the same east to west (the Producing Company operates outside this area); 4) service to 458 cities and towns in Texas and Oklahoma; 5) service to a population of some 3,300,000 people; 6) operation of more than 8000 miles of transmission and gathering pipelines and more than 11,000 miles of distribution mains; 7) a

gas supply taken from more than 300 producing reservoirs and more than 13,000 wells, and 8) maintenance and use of five underground storage reservoirs, having a gross capacity of 52.5 billion CF.

Foreign Activities

Federation of the Gas Industry: Report of the Visit to the USSR, under OEEC Sponsorship — October 10-20, 1958. *Rev. Gen. du Gaz 81,* 34 (1959) Mar.-Apr. (28 pp. French text.)

Three-man team of Belgian gas engineers headed by R. H. Touwaide spent 10 days in Russia while a Russian team exchanged a similar visit in Belgium. The over-all report consists of two parts, Part 1 on the Russian utility gas industry presented here, and Part 2 on underground gasification which appears in the *Annales Mines de Belgique*. Part 1, presented in five sections, begins with the general situation and perspective. Here the 1957 crude production figure of 87,429 million m^3, comprising only 4% of USSR energy consumption, is compared with the Belgian and United Kingdom data. New fields in Central Asia, the Ukraine and Stavropol are mentioned and old and projected pipelines are mapped and tabulated. Lines up to 2000 km long and with a maximum diameter of 1m are under construction to carry 150 billion m^3 gas by 1965. This will include gas manufactured from lignite and underground gas. The second section describes the Leningrad supply, as based on coke oven gas (Vorkuta coal) and shale gas (Kohtla-Jarve and Slantz). Manufacture, distribution, and customers (290,000) are discussed. Annual consumption now is 400 million m^3/yr; by 1962 expanded consumption should reach 6,350 million m^3 with the addition of new natural gas lines. Moscow, briefly described, currently consumes about 10,000 million m^3/yr; in 1962 this figure is expected to reach 21,000 million m^3. In Section 3, Russian practice in high-pressure tank storage and design is described. The Moscow methane liquefaction storage plant is described in some detail in Section 4. Since 1954, this ammonia-ethylene-methane liquefaction system has been operating together with a 195,000 m^3 insulated storage installation. Section 5 deals with utilization of low calorific value gas (85 to 160 Btu/CF) such as manufactured by underground gasification plants. Injection burners with perforated plate ports, backed by a stabilizing metallic grill, and the Pamphilov perforated ceramic port burners are discussed.

Russia Revises Pipeline Goals. C. L. Adams. *Petrol. Eng. 31,* D-34 (1959) June (5 pp.)

USSR's urgent need for a greatly expanded oil and gas pipeline system is readily apparent. Even during 1958, when crude production was only 113,000,000 metric tons and gas output was 29.8 billion CM, Soviet officials complained of pipeline bottlenecks. New seven-year plan, which begins this year, calls for 34,775 miles of pipeline construction reaching beyond natural borders of the USSR to satellite countries and possibly Finland and Sweden.

Sui-Multan Pipeline Is Asia's Second Long Transmission System. V. S. Swaminathan. *Petrol. Eng. 31,* D-48 (1959) June (2 pp.)

Completion of the 384-mile Sui-Multan pipeline in West Pakistan is the first phase of a comprehensive plan to provide natural gas to industrial consumers in the northern areas of Pakistan. The second phase calls for extension of the line to Lyallpur, a waxing industrial center in the rich canal colonies. In the third phase the line will reach Lahore. On completion of these undertakings, which will involve the laying of 200 miles of pipeline, the whole of western Pakistan will have inexpensive energy.

Laying of Chhatak Gasline to Begin Late This Year. *Progress 3,* 3 (1959) May.

Four-in. diam., 12-mile long gas transmission line along the banks of the Surma River will supply natural gas from Chhatak field (East Pakistan) to the Assam Bengal Cement Works. Present estimate of proved recoverable reserves is about 20,000 MMCF, which would produce 5 MMCF/day of gas for about 11 years. Initially gas will be produced from the 3600-ft and 4200-ft sand group.

What's the Outlook for Argentina's Oil Industry? *Petrol. Week 8,* 48 (1959) June 12 (3 pp.)

Within the year that Argentina first opened its doors to foreign oil-company assistance, 17,850 sq miles of land have been awarded to one British and five U.S. companies for exploration, drilling and oil development. This compares with only 190 sq miles of concession areas awarded to two foreign oil companies during the previous 50 years. During the year, new foreign capital pledged for investment in Argentina's oil industry totaled some $535 million.

Electricity

A Gas Utility Man Speaks Out on Electric Heating. G. R. Nelson. *Gas Ind. 3,* 2 (1959) July (2 pp.)

Point by point analysis of how electric heating compares with the advantages gas affords. Author cites concrete examples of statements issued by the electric industry in regard to operating costs, often considered as the most important feature by a potential customer. To prove his stand on gas heating, he then cites actual case histories. His conclusions: Gas heat offers the maximum in economy, cleanliness, safety and comfort.

A Manufacturer Speaks Out on Electric Heating. L. A. Brand. *Gas Ind. 3,* 3 (1959) July (4 pp.)

Author examines the electric industry's promotional campaigns regarding modernity, cleanliness, comfort, economy, convenience, initial cost, safety, zone heating, maintenance cost, quiet operation and future fuel supply. He then uses figures to compare heating costs, determine heat replacement values of various fuels, compare heating efficiencies and to calculate the price at which electricity would have to sell to be competitive with city gas, LPG, oil and coal.

Space Heating

Oil Heat: Ailing or Thriving? *Nat. Petrol. News 15,* 107 (1959) June.

It all depends on interpretation. If the Oil-Heat Institute's figures on 1958's net gain of new oil users are compared with gains shown by other automatic fuels, oil heat is on the wane. However, the annual report of OHI's distribution division reports gains in members, in the sale of promotional material to its members, and in insurance plan coverage. Furthermore, it forecasts greater future gains. Here's what the net gain figures show: Gas: 1,089,000 new users; electric heat: 128,000; oil heat: 39,000; coal: net loss of 164,000.

Oil Heat Unity Drive Is On. *Nat. Petrol. News 51,* 105 (1959) June (2 pp.)

Concentrated drive to form one over-all heating oil trade association is underway. Target date is 1960. Objective of organization would be to enable oil heat to compete successfully with natural gas, which in less than a decade has become a grave threat to oil heat's future. It has captured a big share of the new-home market and is moving in on oil heat's existing business. It is planned to group the following activities and organizations: the API fuel oil committee, the API fuel oil research program, the National Fuel Oil Council, the Oil Heat Institute of America, Operation Oil Heat Associates and related activities. Recommendation proposes that the new organization consist of four divisions: Manufacturers, distributors, refiners and oil suppliers, and research and technical.

Cookers

Who's Getting the Commercial Cooking Load? C. C. Turner. *LP-Gas 19,* 27 (1959) June (6 pp.)

Article presents 24 reasons why electric competition has cut LPG's percentage of the commercial cooking market from 90 to about 58%. These reasons indicate that LPG industry is guilty of confusion, lack of coordinated effort and poor salesmanship. Modern appliances offer LPG men the opportunity to recapture the 90% spot, but the path is not easy. Job involves selling performance instead of price, engaging in a coordinated educational program, eliminating internal bickering, cooperating with equipment suppliers and giving the food processors the things they really want. None of these measures eliminate life blood of the LPG business—healthy competition.

Air Conditioning

New Spurt in Home Air Coolers? *Business Week 1557,* 75 (1959) July 4 (2 pp.)

Room air conditioners attained a sales record of 1,828,000 units in 1956, but in 1958 had skidded to 1,550,000. Central units, in 1956, reached 160,000 units, stalled at this level in 1957 and slipped a little in 1958. Now new selling techniques and an early-season rise in sales are making 1959 begin to look like the year home air conditioning will emerge from its sales slump and reestablish itself as a robust growth industry.

Federal Power Commission

Improving the Regulatory Process. O. Harris. *Public Util. Fortnightly 64,* 19 (1959) July 2 (8 pp.)

Subcommittee on Legislative Oversight seeks to help federal regulatory agencies by changing or improving restrictive and vague legislation, relieving them of operational difficulties and improper pressures and influences. Even though commissions are adopting many rules and regulations to help themselves, it is still most essential that legislative control be exercised by Congress.

State Commissions

The Triumph of State Commission Regulation. M. L. McWhorter. *Public Util. Fortnightly 64,* 1 (1959) July 2 (9 pp.)

Fine record of progress chalked up by regulatory commissions during the past three decades has proved beyond all question their basic soundness. Commissions have played an important part in preserving private enterprise for the utility industry. But unless this country strives to maintain its dual federal-state system of government, abusive discriminations will continue that contradict the essential reason for the existence of regulatory agencies.

Petrochemicals

Phillips Aims at 'Built-in Value'. *Business Week 1556,* 150 (1959) June 27 (6 pp.)

Phillips Petroleum Co. is one of the largest holders, producers and sellers of natural gas. While its oil production accounts for about 2% of total U.S.

output, its gas production adds up to 7%. In 1958, natural gas sales totaled $77 million, about 7% of Phillips' total revenue. Much of it was sold to the long-distance gas pipelines under long-term contracts, but an increasing amount now is going into petrochemical plants. Its huge gas reserves, together with a top-notch research and development program, have put Phillips deeply intro petrochemicals. Right now, its chief products consist of carbon black, synthetic rubber and butadiene, a wide range of fertilizers, ethylene and polyethylene for plastics, and cyclohexane and a wide assortment of other chemicals for use in making synthetic fibers. Last year, petrochemicals accounted for sales of over $150 million, or some 15% of Phillips' business.

Methane Liquefaction

Venezuela 'Wants In' on Liquid Methane. *Petrol. Week 9,* 76 (1959) July 10 (2 pp.)

Venezuela wants a share of oil company profits in transporting and marketing liquid methane as a condition for setting up natural gas liquefying plants in that country. New offers by Constock Liquid Methane Corp. and Hidrocarburos S.A. to set up liquid gas plants are being studied. The original offers from two U.S. groups have been rejected as "not satisfying the interests of the country." Constock's offer is for a plant at Puerto La Cruz to liquefy gas supplied by Mobil Oil Co. de Venezuela; Hidrocarburos S.A. has offered to build a plant north of Maracaibo. The company was set up by Texas Gas Transmission Corp.; Godfrey L. Cabot, Inc., Boston, and other investment firms. In addition, or as an alternative, the Venezuelan government itself may build plants to liquefy methane for export.

Customer Service

A Guide to Training Servicemen. Part 3. Gas Air Conditioners. J. A. Hayes. *Gas 35,* 78 (1959) July (4 pp.)

Use of expertly trained servicemen to give prompt and thorough air conditioning service has paid off in increased sales of gas air conditioners for Lone Star Gas. Co.'s Dallas division of distribution. To train its servicemen, company offers two 40-hour courses of instruction, one for relatively inexperienced personnel and an advanced service school for those who have already acquired considerable experience. Contents of both courses are outlined. Employees who have completed both courses participate in an annual review and study new equipment and modifications to existing equipment.

Research

Information through Documentation. T. W. Schwartz. *Petrol. Refiner 38,* 299 (1959) June (7 pp.)

Engineering has matured into a dynamic force, but unfortunately, present methods of storing and retrieving information have not kept pace. Better designs would be possible, for example, if all the right information were available. Much duplication of engineering effort occurs because of inadequate documentation. Article describes system DuPont employed to overcome some of these problems.

Safety

Design for a Practical Safety Program. S. Owens. Part 1. *Petrol. Eng. 31,* D-59 (1959) May (3 pp.); Part 2. *Ibid.,* D-60 (1959) June (6 pp.)

Although this series of articles is on the subject of tailoring a safety organization to a pipeline company, it can be applied to all industries. In Part 1, author outlines nine major sections for safety organization standards and discusses the first of these, the safety department — its place in the company organization and responsibilities and functions of the safety director. In Part 2 the employee safety training meetings are discussed.

2. ENERGY SUPPLY AND ECONOMICS

Gas Reserves

Gas Conservation Becoming Popular in Saudi Arabia. P. E. Swain. *Oil Gas J. 57,* 84 (1959) June 15 (2 pp.)

Arabs are beginning to regard the flare with the same offensive view as a member of the Texas Railroad Commission, even though Middle East gas has no market as a fuel — yet. Aramco is the acknowledged leader in the trend to reinject the gas to maintain reservoir pressures and produce more of the oil in place.

Development and Evaluation of Gas-Condensate Reservoirs. Part 3. W. C. Goodson. *Petrol. Eng. 31,* B-107 (1959) June (2 pp.)

When the field has been developed, tested and evaluated and found to have considerable reserves, the key factor in the entire appraisal or evaluation becomes apparent—negotiation of the gas purchase contract. Bearing in mind the increased demand and value of natural gas, the author discusses some of the ideas to consider in negotiation of such contracts both for interstate and intrastate gas sales.

Coal Production

Strip Mining Gets a 2,100-Ton Helper. *Business Week 1556,* 146 (1959) June 27 (2 pp.)

Biggest strip miner of its type in the U.S. weighs 2100 tons, towers 150 ft high and can move 3500

cu yd of dirt a distance of 450 ft/hr. Kolbe Wheel Excavator was unveiled in June by United Electric Coal Companies of Chicago. It is the latest of four such digging wheels that the company has developed for its own use. United Electric, one of the first coal companies to mine bituminous coal by stripping off the overlying earth, is one of the largest U.S. companies mining coal exclusively by stripping.

Fuel Cells

The Fuel Cell . . . Status and Background. H. A. Liebhafsky and D. L. Douglas. New York: ASME Paper No. 59-SA-22, 1959; $.80 ($.40 to members); (9 pp.)

Review of the broad aspects of the fuel cell problem leads to the following conclusions: Cells for special applications will use hydrogen and should be ready for use within five years. Any cells for the generation of electricity on a central station scale would probably use gases containing carbon compounds as fuel. Although recent progress on such cells is gratifying, the problems they present are so formidable and the requirements they must meet are so exacting, that it seems unwise to predict when they might be commercially successful.

New Family of Power Producers. *Business Week 1556,* 45 (1959) June 27 (5 pp.)

Numerous companies are working on fuel cells. Combining chemicals, a fuel cell gives electricity directly with no intermediate heat, engine or generator. It is the kind of process that makes a flashlight battery function. Now new materials and methods make the fuel cell many, many times as powerful and efficient.

Gas Turbines

Gas-Turbine Score: 281 Units. J. C. Reidel and G. T. Kinney. *Oil Gas J. 57,* 71 (1959) June 29 (3 pp.)

During the past ten years, the gas turbine has entered the petroleum industry and has risen rapidly to a position of prominence. From the first experimental installation as a compressor drive in natural gas transmission in 1949, gas turbine applications have mushroomed to a total of 1,364,865 hp and 276,900 kw in the pipeline, producing, refining and petrochemical branches of the industry. Two-page tabular breakdown according to these classifications indicates the company using the turbine, application, no. of units for each company and total of hp or kw installed.

Space Heating

Heating an "Unheatable" Building. *Gas 35,* 71 (1959) July (3 pp.)

Construction company in Kentucky installed individual gas-fired infrared heat generators to provide direct heat for 14,000 sq ft of its 16,000 sq ft structure. (Remaining 2000 sq ft are completely enclosed areas heated by forced air furnaces.) Perfection-Schwank generators convert 100% of the fuel energy to usable heat at a greater degree of efficiency in respect to worker comfort at 30% less cost than any other system. Heating cost for the 1957-58 season, at $00.566/MCF of natural gas, was $820.07 for a 235-day season of 3383 degree days. The building was heated 24 hr/day. Cost per sq ft for the season was $0.056.

Heat Pump

Performance of an Air Source Compound Heat Pump. A. D. Spillman. *ASHRAE J. 1,* 38 (1959) June (4 pp.)

Air appears to be the most promising future source of heat for heat pump installations, limited only by the availability of dependable equipment to give efficient year-round heating and cooling comfort. Recently, compound or multi-stage compression machines have been adapted to operate at reduced compression ratios, with increased output, and higher performance efficiencies. With these, auxiliary resistance heaters are not necessary. These developments prompted an investigation of the heat pump as a suitable means of heating and cooling a specific Philadelphia office building.

Exploration

Iran Opens New Areas for Operating Agreements. G. E. Grays, G. W. Underwood and T. B. Young. *Oil Gas J. 57,* 90 (1959) June 22 (7 pp.)

Iran has recently declared three large areas available to foreign capital for operating agreements. Sedimentary basins in which the environment is favorable for the occurrence of petroleum cover more than 312,000 sq miles on the continent and 39,000 sq miles along the Continental Shelves of the Persian Gulf, Gulf of Oman and the Arabian Sea.

Stage Set for Important Persian Gulf Wildcat. P. E. Swain. *Oil Gas J. 57,* 88 (1959) July 6 (2 pp.)

Japanese-organized Arabian Oil Co. will conduct an 8000-ft Arab zone test in 102 ft of water 25 miles north-northeast of the closest Safaniya (Aramco) field. Seismic work done by the Japanese found a structure which they hope will put them in the oil business overnight. At the time they staked their first location, they spotted No. 2 and No. 3. The second test already staked is 20 miles west-northwest of the first. The third will be just halfway between the two.

Thermoelectricity

Optimization of a Conventional-Fuel-Fired Thermoelectric Generator. B. W. Swanson and E. V. Somers. New York: ASME Paper No. 59-CA-14, 1959 $.80 ($.40 to members); (4 pp.)

Investigation of conditions for optimizing the thermal efficiency of the design of a conventional-fuel-fired thermoelectric generator is reported. Equations are developed for 1) the temperature distribution of the heated gas in a circular duct type of generator, that maximizes the thermoelectric power output, with respect to the temperature distribution within the duct and the exit gas temperature at the end of the duct; 2) the thermoelectric power developed, based upon these optimizing temperature criteria; 3) the required variation of thermoelectric element thickness required to satisfy both optimizing temperature criteria, and 4) thermal efficiency under optimum conditions.

The Thermionic Converter. V. C. Wilson. New York: ASME Paper No. 59-SA-23, 1959; $.80 ($.40 to members); (8 pp.)

Thermionic converter is a vacuum or gas-filled device with a hot electron emitter and a cold collector. Heat lifts some of the electrons in the emitter to a high potential position outside the emitter. If the electrons are collected on a metal with a low work-function surface, some of this potential may be conserved to drive the electrons in an external circuit to do useful work. Space charge between the electrodes may be reduced by close spacing or by neutralization by positive ions. Calculations have been made to determine the optimum conditions to obtain maximum power outputs and maximum efficiencies. Theoretical and experimental results for the closely spaced vacuum converter and for two methods of operating gas-filled converters are given. Some possible applications are discussed.

Thermionic Converters. K. G. Hernqvist. *Nucleonics 17,* 49 (1959) July (5 pp.)

Thermionic conversion, a method of converting heat directly into electricity, promises to have the highest efficiency of all the direct-conversion schemes. Where thermoelectric converters, for example, must strain to get thermal efficiencies of 10%, thermionic converters look forward to efficiencies as high as 25-30%—almost the same as the efficiencies of present-day central power stations. But this excellent performance requires a heat source that can operate at quite high temperatures (around 1100° C, or 2000° F.) Combined with nuclear fuels these cells offer exciting possibilities.

Los Alamos Plasma Thermocouple. G. M. Grover. *Nucleonics 17,* 54 (1959) July (2 pp.)

Experiments at Los Alamos (N. M.) on thermionic converters have resulted in the successful conversion of heat from fissioning material directly into electricity. A plasma thermocouple was used in these experiments. It was operated in the core of a Los Alamos research reactor generated closed-circuit currents as high as 35 amps and an open-circuit voltage of 3.8 volts, indicating a power output through a matched load of the order of 30 watts.

Tar Sands

Recovery of Oil from Tar Sands. T. M. Doscher and J. Reisberg (assigned to Shell Development Co.) U.S. 2,882,973 (1959) Apr. 21.

Process of recovering oil from oil or tar sands is claimed in which an aqueous solution of *p*H 12, containing 0.1-5% by wt of non-ionic surfactant (oxyethylated octyl or nonyl phenols) is contacted with the oil sand in the formation, and the resulting emulsion recovered and separated.

Thermoelectricity

Thermoelectric Heat-Pumps. N. E. Lindenblad (assigned to RCA.) U.S. 2,884,762 (1959) May 5.

Thermoelectric heat pump is claimed comprising two banks of thermocouples. These banks are spaced and thermally isolated from each other, the solid-conducting hot and cold junctions arranged so that the cold junctions of the first bank are connected thermally with hot junctions of the second bank by tubing carrying a circulating heat exchange medium, thereby producing a cascade effect in dissipating the heat.

3. NATURAL GAS AND PETROLEUM PRODUCTION

Adsorption

How to Determine Payout of Wellhead Adsorption Units. F. H. Plitt. *World Oil 148,* 120 (1959) June (4 pp.)

Economic evaluation of an adsorption system should include a complete reservoir study, a determination of expected daily gas deliverability, system pressure and temperature, fractional analysis of the wet gas stream and desired recovery. Such an evaluation will reveal the ultimate yield in dollars returned per dollar invested. Objective of article is not to show ultimate status, but to indicate the payout period of such equipment at varying conditions of gas content and volume rate. Study may prove to be a guide to the operator confronted with producing lean gaseous streams at the optimum economic return possible.

Drilling

The Downhole Drill String: An Engineering Triumph. R. O. Frederick. *Drilling 20,* 66 (1959) June (6 pp.)

Most dramatic achievement in earth boring equipment in a century marked with advancements is a precision engineered assembly of drill pipe, tool joints, drill collars, bit and auxiliary tools — the deceptively simple appearing downhole drill string of the modern rotary rig. Résume of some of the outstanding advancements of the last 100 years, particularly the latter 58 years.

Exploration

Exploration in Philippines Progressing. C. E. Workman. *World Oil 148,* 154 (1959) June (4 pp.)

Oil shows in several wells give promise of future production. Tertiary beds link production trend between Indonesia to the south and Taiwan and Japan to the north. Standard-Vacuum Oil Co. discovered gas at Ipil 1 in August, 1958. Remote location is on Luzon, in the southern part of the Cagayan basin near the town of Echague, Isabela Province (about 200 miles north of Manila). A total of 71,936,000 CF of dry gas was flared during a 10-day deliverability test in October.

Logging

Varied Logging Program Required in the Paradox Basin. F. S. Millard. *World Oil 148,* 141 (1959) June (5 pp.)

Well logs are being used by operators in the Paradox basin for correlation and, to a limited extent, for evaluation of the Hermosa formation. Problem of correlation can best be solved by use of the gamma ray-neutron log or continuous velocity log. Log analysis of the Hermosa is extremely difficult due to the nature of the formation. Neutron, velocity and density logs are being used to evaluate porosity. Spontaneous potential curve serves as a guide to location of permeable zones and a determination of formation water resistivity. Focused logs, including induction logs, are used extensively to estimate true resistivity and as a means of evaluating connate water saturation.

Offshore Operations

Going Abroad? Try an Offshore Site! *Oil Gas J. 57,* 65 (1959) June 22 (3 pp.)

Ocean Drilling & Exploration Co.'s (ODECO) president, a strong advocate of foreign offshore drilling, believes that it is cheaper to drill offshore than onshore in many areas of the world (estimate: $500,000). Chances of finding oil are just as good. Pitfalls prevail for the uninitiated, but the basic premise is sound. ODECO's president tells how it can be done.

Multiple Completions Put Profit in Offshore Wells. W. W. Poimboeuf, Jr. and W. W. Cleply. *Oil Gas J. 57,* 102 (1959) June 15 (4 pp.)

Economics and conservation are the major advantages of multiple completions. Without the multiple completion, drilling in deep water would be economically impractical. The deeper the water the higher the cost of drilling and producing. And, the multiple completion enables the offshore operator to venture into deeper water. Without it, he would be forced to develop only in very shallow water or onshore where the return is reasonable. If the offshore operator finds the multiple completion attractive, the onshore operator should find it more so. Production of several zones from one well can mean the difference between financial success or failure. This is especially true where formations are thin or otherwise marginal.

Reservoir Engineering

Calculations of Flowing and Static Bottom-Hole Pressures of Natural Gas Wells from Surface Measurements. P. B. Crawford and G. Fancher. Texas Petrol. Res. Comm. Bull. No. 72. (Austin: University of Texas; $5.00.) 1959 (198 pp.)

Report of a program conducted by the Texas Petroleum Research Committee for the Natural Gas Department of the Railroad Commission of Texas for the development of improved methods of estimating the static and flowing bottom-hole pressure from surface pressure measurements. For accurate and precise results, the calculations are tedious, requiring trial and error procedure or, if the calculations are simplified, the results are too inaccurate for most practical applications. Publication contains 137 charts which have been prepared to assist the engineer in computing both static and flowing bottom-hole pressures of gas wells from surface measurements. Charts are arranged in three groups: 1) Ninety charts for calculation of flowing and static bottom-hole pressures of the average natural gas well. Charts may be used for well depths to 15,000 ft and for reservoir pressures not exceeding 6000 psia. 2) Twenty-one charts for estimating the static or shut-in bottom-hole pressures of low pressure gas wells. These charts are applicable for ranges in reservoir pressures to 1200 psia and well depths to 15,000 ft. 3) Twenty-six charts for estimating the static bottom-hole pressures of high pressure gas wells. These are applicable for well depths to 20,000 ft and reservoir pressures to 14,000 psia.

Secondary Recovery

Control of Injection Gas Composition in Enriched Gas-Drive Projects. T. N. 2035. J. K. Elliott and H. C. Johnson. *J. Petrol. Tech. 11,* 63 (1959) June (2 pp.)

One of the primary requirements for successful operation of an enriched gas-drive project is to control the composition of injection gas. This can become a serious and difficult problem, particularly in cases where the enrichment material is being furnished from a number of field-produced gas streams. Article discusses technique that was used successfully on an operating enriched gas-drive project for developing information which could be used for controlling composition of the injected gas.

The Effect of Viscosity Ratio and Path Length in Miscible Displacement in Porous Media. R. L. Slobod, E. J. Burcik and B. H. Cashdollar. *Producers Monthly 23,* 11 (1959) June (6 pp.)

Report on the length of the mixing zone as a function of path length for different viscosity ratios. Some attention is directed to the growth of the mixing zone for favorable viscosity ratios, but most of the experimental work was devoted to studying the development of the mixing zone for unfavorable viscosity ratios wherein fingering is present and longer mixing zones could be expected. Prime objective of this work was to show the beneficial effects of long path length on the growth of the mixing zones for this unfavorable viscosity case. It can be concluded that the absolute length of the mixing zone increases with distance traveled; that is, the mixing zone does not stabilize. The length of the mixing zone on a pore volume basis, however, decreases with the path length. This behavior makes possible the use of relatively small slugs of miscible phase in reservoirs using relatively long flow paths.

Well Practice

DST—Success or Failure? J. Grynberg. *Oil Gas J. 57,* 106 (1959) June 22 (7 pp.)

With the ever-increasing difficulty in the discovery of oil reserves within the U.S. today, it is important to completely and conclusively evaluate every possible productive reservoir. The nature of an oil operator is such that, when he observes a recovery of only the slightest amount of water, he immediately condemns the reservoir and with it the well if no additional prospects occur. A watchful and rational approach in evaluating drill-stem, formation-fluid sampler, and production-test data would eliminate the bypassing of commercial hydrocarbon reservoirs from which water, that is really mud filtrate, is recovered. In view of the past lackadaisical evaluation of test results and data, it is believed that numerous commercial fields have been bypassed.

New Perforating Method Developed. *Oil Gas J. 57,* 68 (1959) June 15 (3 pp.)

New erosion method of perforating wells, developed by Western Co., tentatively named Hydra-Perf, utilizes a directed stream of abrasive containing fluid to cut holes through casing, cement and pay formation. It is fast and powerful. Average time consumed in perforating is only about 3 minutes, and resulting perforations into the formation are measured in feet rather than inches. Company thinks method may eventually replace conventional jet and bullet perforating.

Ohio Takes a Look at Slim Hole Completions. B. Johnson. *Drilling 20,* 79 (1959) June (5 pp.)

Recent survey of the construction and equipment costs of Clinton wells completed by a large Ohio producer reveals that during the past five years, increased costs have averaged nearly 8%/yr whereas crude prices are at practically the same level as they were a decade ago. While the Ohio producer is limited by economics from conducting any sizable research or experimental projects, he must be aware of and quick to apply any development or method which might reduce operating costs. With these points in mind, Natol Corp. initiated a project in June, 1958, to consider the design and testing of scaled-down slimhole production equipment. Objective was to determine whether a Clinton well can be successfully produced in very small casing strings and whether the method and equipment can be utilized with savings and to what extent.

Volcanic Ash (Pozzolan) Improves Oil Field Cementing Practices. C. M. Stout and J. E. Strassner. *World Oil 148,* 114 (1959) June (5 pp.)

Pozzolanas are usually defined as materials which, though not cementitious in themselves, contain constituents which will combine with lime in the presence of water at ordinary temperatures to form stable, insoluble compounds possessing cementing properties. Advantages of pozzolanic additives over neat portland slurries are reduction in cost of cementing materials by producing greater yields but also yielding slurries having lighter densities; lower fluid loss; better perforating characteristics, and greater resistance to oil well fluids.

Drilling

Rock-Piercing Method and Blowpipe. C. A. Napiorski (assigned to Union Carbide Corp.) U.S. 2,882,017 (1959) Apr. 14.

In a blowpipe method for piercing meltable rock strata, it is claimed that complete melting is fore-

stalled and "drilling" progress by spalling action is improved by reduction of flame gas speeds to subsonic velocities. This is attained by proper dimensioning (alternate divergence and convergence) of flame gas passages.

Thermal Mineral Piercing Employing a Free Suspension Blowpipe. R. B. Aitchison and G. H. Smith (assigned to Union Carbide Corp.) U.S. 2,882,016 (1959) Apr. 14.

Method of thermally piercing mineral bodies is claimed in which oxy-fuel flames are directed at high pressure from a blowpipe against the body to spall away the mineral by heat, lowering the blowpipe by cable as the hole is deepened, and reciprocating the blowpipe at 25-65 cpm for a 5-in. stroke to maintain the flame at effective distance for action.

4. GAS CONDITIONING AND LPG RECOVERY

Carbon Dioxide Removal

Freezing CO_2 from Natural Gas. W. E. Clark and F. Kurata. *Petrol. Refiner 38,* 249 (1959) June (3 pp.)

Article introduces a different method for removal of carbon dioxide, that of freezing out of the CO_2. This method may be more economical in many cases. Only a preliminary investigation has been conducted, but it is sufficient to indicate that the freezing method has promise. According to the data published by Donnelly and Katz for the carbon dioxide-methane binary (see *Gas Abstracts 9,* 159 and *Gas Abstracts 10,* 110), carbon dioxide can separate from methane as an almost pure solid phase at low temperatures. Therefore, unless other constituents interfere, a simple solids-gas separator such as a cyclone can be used to remove carbon dioxide from natural gas.

Hydrogen Sulfide Removal

Today's Processes for Gas Purification. A. L. Kohl and F. C. Riesenfeld. *Chem. Eng. 66,* 127 (1959) June 15 (52 pp.)

Special report, based on a book to be published in January, 1960, concentrates on the processes available so that the reader can evaluate alternate routes to solving his gas purification problems. About 80% of the actual book is devoted to operation and design aspects. Article covers use of ethanolamines, aqueous NH_3, alkaline salts and water as absorbents, removal of SO_2, basic nitrogen and water, processes on oxidation of H_2S, catalytic conversion and other purification techniques.

Carbon Dioxide Removal

Process of Removing Carbon Dioxide from Natural Gas. P. E. Bocquet (assigned to Constock Liquid Methane Corp.) U.S. 2,888,807 (1959) June 2.

Carbon dioxide is removed from mixture with methane by a double distillation system in which the first tower is held below 673 psia (critical pressure of methane). Methane reflux and bottoms of the first still are used as feed for the second still where pressure is controlled at just above the solidification point to remove carbon dioxide.

Separation of Gaseous Mixtures. J. V. Fetterman (assigned to Air Products Inc.) U.S. 2,881,595 (1959) Apr. 14.

Improved air fractionation system is claimed in which only a small portion of the CO_2 removal interchanger is provided in duplicate and conditions of exchange are controlled to allow for a reduction in equipment and in heat loss along with complete CO_2 removal.

Dust Removal

Louvered Coolant Fluid Ash Quenching Systems for Pressurized Combustors Utilizing Powdered Coal. J. I. Yellott and P. R. Broadley (assigned to Bituminous Coal Research, Inc.) U.S. 2,888,804 (1959) June 2.

Improved ash quenching for powdered coal-burning turbine systems is claimed in which the heavier unburned coal residues are separated from combustion gases by projecting them from the stream of combustion gases into a downcomer where they are cooled by secondary air entering through louvres and then passed to inlets of special tube ash separators for removal.

Hydrogen Sulfide Removal

Conversion of Methane to Produce Hydrogen Sulfide. P. S. Viles (assigned to Esso Research and Engineering Co.) U.S. 2,887,363 (1959) May 19.

Cobalt molybdate catalyst on aluminum is used at 1200° F and 0-1000 psig to convert SO_2 in an excess of methane into hydrogen sulfide which then may be recovered.

Method for Recovery of Sulfur from Hydrogen Sulfide-Containing Gases. T. Q. Eliot (assigned to Pan American Petroleum Corp.) U.S. 2,889,207 (1959) June 2.

In the usual Klaus kiln process of sulfur recovery from hydrogen sulfide-containing gases an improvement is claimed in which hydrocarbon gas (methane) is added to the H_2S gas feed in amount of one-third of the H_2S present (molar basis). In the subsequent oxidation step, the hydrocarbon is reformed

giving equilibria which reduce the formation of water and carbon oxysulfide in combustion gases, and increase the yield of free sulfur.

Method of Removing Carbon Dioxide and Hydrogen Sulfide from Gases. F. Baumann. U.S. 2,889,-197 (1959) June 2.

In a process for removal of H_2S and CO_2 from synthesis gas, the improvement claimed consists of removal of H_2S in one or more stages by an ammonia washing solution containing a salt such as iron sulfate which reacts in solution to precipitate iron sulfide which is filtered and recovered, and ammonium sulfate which is crystallized and recovered. Gas is then scrubbed with ammonia solution containing alkali metal hydroxides whereby the less soluble sodium bicarbonate is precipitated and removed, and the scrubbing repeated similarly in one or more stages with a final acid washing with dilute acid to recover ammonia.

5. NATURAL GAS TRANSMISSION

Automation

Fire Protection for Unattended Pump Stations. G. L. Ladd. *Petrol. Eng. 31,* D-72 (1959) June (2 pp.)

Utilization of the unattended pump station in pipeline operations has brought about new problems, and make more complex some of the old ones. Prevention of, and protection from, explosions and fires is of the latter category. Safer and more reliable protection would be obtained if automatic equipment was used. Should fire occur, automatic detectors could actuate automatic extinguisher equipment to control the fire. Extinguisher equipment generally consists of large cylinders of CO_2 connected to a piping system, through which the inert gas, under its own pressure, floods the fire through multi-jet nozzles. CO_2 reduces the oxygen in the atmosphere and will smother a fire in seconds. System should be designed and so arranged that the operating power supply, detector units and actuating unit circuits, and alarm circuits will be supervised automatically.

Compressibility

Utilization of Surplus Pressure Energy of Natural Gas. A. V. Aleksandrov. *Gazovaya Prom.,* 38 (1959) No. 6 (5 pp. Russian text.)

Surplus energy of natural gas can be utilized at the well or at the final point of use for the production of electricity or refrigeration. Formulas and graphs are given for calculation of electrical power as a function of mass flow, pressure drop and preheat when natural gas is allowed to expand in a turbogenerator. Steam turbines can be used without major alterations.

J. W. Penney

Compressor Stations

Remote Control of a Large Single-Unit Gas-Turbine Compressor Station. P. Reed and G. T. Kinney. *Oil Gas J. 57,* 74 (1959) June 29 (5 pp.)

Texas Eastern Transmission Corp. on its Penn-Jersey system is remotely operating four single-unit stations each powered by a 13,400-hp gas turbine, the largest on any pipeline. Turbine drives a two-stage centrifugal compressor at 4860 rpm. Remote-controlled system has met the requirements of low investment and operating costs despite a widely varying load.

Fluid Flow

Friction Factors for Turbulent Flow in Curved Pipes. H. Ito. *J. Basic Eng. 81,* 123 (1959) June (12 pp.)

Objective of article is to furnish engineer with reliable data on the friction factors to be used in computing pressure losses for turbulent flow in smooth curved pipes. Empirical formulas proposed, backed by theoretical considerations, appear to define the influence of curvature upon the law of resistance with satisfactory accuracy.

Pipe Line Flow Tests Conducted on 24-Inch Gas Line Near Refugio, Texas. C. Klohn. *Pipe Line News 31,* 44 (1959) June (7 pp.)

Series of flow tests was conducted on an 11.896-mile section of 24-in. O.D. x 250-in. W.T. pipe. A range of flow rates was established from 150 MMCFD to 450 MMCFD in increments of approximately 50 MMCFD. Purpose of tests was to discover if interior cleaning or interior coating had any effect upon the deliverability of a natural gas pipeline.

Universal Pressure Distribution in Gas Pipelines. D. O. Atkinson and P. B. Crawford. *Gas 35,* 111 (1959) July (7 pp.)

Universal pressure distribution curve has been developed for gas pipelines. Use of the procedures permits more accurate gas pipeline computations than has been previously practical. A method has been devised for integrating the horizontal gas flow equation which results in general curves showing the pressure distribution for all pipeline systems for values of reduced pressure from near 0.01 to $15.0P_r$ and values of reduced temperature from 1.05 to 300 T_r.

Pipeline Construction

Coastal Transmission Combines Proven Methods with Promising Advances. M. A. Judah and D. G. de Pugh. *Pipe Line Ind. 10,* 40 (1959) June (6 pp.)

Despite heavy rains which halted construction early in 1959, Coastal Transmission Corp. completed its 561-mile main line ahead of time for its delivery commitment to Houston Texas Gas & Oil Corp. Coastal utilized full automatic railhead double-jointing on 79 miles of 24-in. In laying an 11-mile crossing of the Galveston Bay, Brown & Root, Inc., employed lay barge plus spud barge to pull the line under the Houston Ship Channel allowing traffic to move through the bay. Station design includes unitized compressor engine driven auxiliaries and facilities for on-stream pigging.

Survey Pipeline Routes by Radar. M. E. Fuller. *Gas 35,* 118 (1959) July (4 pp.)

Recently developed survey instrument—a Tellurometer—was used for the first time on a gas pipeline job for the Pacific Lighting Gas Supply Co. Instrument saved both time and money. It is designed to perform one function—that of measuring long distances with accuracy and speed. Tellurometer has these characteristics: 1) It is capable of producing accurate results; 2) with precise length measurements, a traverse is a "strong" survey and the results of triangulation can be achieved by traverse with less field and computation time; 3) measurement is speedy; 4) the Tellurometer is of limited usefulness on lines shorter than 500 ft; 5) there is no need to occupy the line being measured except at the ends; 6) measurement is possible without seeing between the master and remote units; 7) the units need not be precisely pointed at each other; 8) steps should be taken to guard against error introduced by interference by other radio waves, and 9) the distance measured is a slope distance.

Pipeline Operations

Pipeline Control Systems. *Petrol. 22,* 215 (1959) June (3 pp.)

Operational control of both gas pipelines and liquid pipelines involves controlling the rate of flow of the fluid products. In both cases, this involves on-off and continuous control of valve settings. Gas lines differ from liquid lines in that gas is propelled by compressors, liquids by pumps. Gas pipelines are primarily controlled on pressure, liquid lines on flow rate. Principles of pipeline control systems as devised by one company are subject of article.

Pipeline Construction

Pipe Line Plugger. B. ver Nooy (assigned to T. D. Williamson, Inc.) U.S. 2,886,068 (1959) May 12.

Plugging device for a pipeline is claimed which comprises a housing transverse to the pipeline to be plugged, a plugging element carried on guides and sliding laterally to a position centered over the pipeline opening. Said element is supported by scissor-linkages which are expandable by a left- and right-hand threaded shaft. As the shaft rotates it moves the plug lengthwise along the pipeline to engage and seal peripherally the pipeline opening.

Pipeline Operations

Pipe Lineup Clamp. J. L. Coody, E. K. Bell and J. S. Work (said Coody assigned to P. Barkley.) U.S. 2,888,895 (1959) June 2.

Pipe lineup clamp is claimed which consists of a pair of sets of arcuate gripping shoes, mounted in a semicircle and hinged together, adapted to bridge the joint between opposed pipe ends to align them, with a latching means for clamping such shoes in closed position and a link and hydraulic jack for final drawing up of the pipe in an aligned position.

6. GAS AND LPG STORAGE

Petroleum Transportation

Sea Transportation of Petroleum. L. F. Kahle and A. J. Kelly, Jr. *Oil Gas J. 57,* 106 (1959) July 6 (3 pp.)

Often oil well and consumer are separated by distances where overland transportation such as pipeline or rail can be used. Taking the U.S. in total, this is generally the case, for out of every 10 bbl of petroleum consumption in this country, only about 3-4 bbl go for an ocean ride along the way; this factor allows for both coastwise tanker movements and for the imports of crude oil and products from overseas areas. Taking the foreign area in total, and excluding the Russian bloc countries, almost 8 bbl out of every 10 of oil consumption move along an ocean trade route. In Europe the figure is still higher—over 90% dependency on ocean transport. During the 40-year period ending in 1958, demand for tanker transportation on the world's trade routes increased from an estimated 168 T2 equivalents in 1918 to 2558. In the first 20 years of this period, oil demand grew 7%/yr vs only about 6.5%/yr for tonnage. In the second 20-year period, demand growth averaged 5.6%/yr and tonnage averaged 7.6%/yr.

Underground Storage

Colorado Utility Tests Coal Mine as Storage Vault. *Gas Age 123,* 19 (1959) June 11 (3 pp.); *Am. Gas J. 186,* 34 (1959) July (2 pp.)

Conversion of a coal mine to a storage vault for natural gas is being undertaken for the first time anywhere in the world by Public Service Co. of Colorado. Abandoned mine gives the utility a 150-MMCF

storage cavern which could hold some 3 billion CF of gas under 300 psi pressure. Testing operations are now being conducted at the Leyden lignite mine, seven miles northwest of Arvada, to determine if the mine is gas tight. If test results are favorable, the cavern will be developed as a permanent storage place.

Liquefaction

Insulated Tank with Impervious Lining. W. L. Morrison (assigned to Constock Liquid Methane Corp.) U.S. 2,889,953 (1959) June 9.

In an internally insulated storage tank for holding liquefied methane, an improvement is claimed consisting of an additional lining of corrugated or crumpled metal foil cemented to the insulation. Such corrugations will permit shifting during metal contraction when loading the tank and leave a scabrous surface to provide points for initiating the boiling of the stored methane.

7. MANUFACTURED GAS AND CHEMICAL PROCESSING

Acetylene

Ethylene, Acetylene from Liquid Feed. *Petrol. Week 9,* 31 (1959) July 3 (2 pp.)

Manufacture of acetylene and ethylene from light liquid hydrocarbons, long used in Europe, is just coming into favor in the U.S. Interestingly enough, the process was first developed in this country, but there was no economic incentive to use it at that time. It was first used in Europe because the supply of gaseous hydrocarbons available for petrochemical manufacture was inadequate. Basic difference between the production of acetylene and ethylene from liquid feedstocks is one of temperature. Difference requires that two entirely different types of installations be built for the application of the same basic process.

Butane

The Oxidation of *iso*Butane. A. N. Bose. *Trans. Faraday Soc. 55,* 778 (1959) May (6 pp.)

Kinetic and analytical studies support the view that the anomalous temperature coefficient in the oxidation of *iso*butane by oxygen is connected with the increasing dissociation of a radical RO_2 responsible for chain-branching.

Coal

The Occurrence of Sulphur in British Coals. A. M. Wandless. *J. Inst. Fuel 32,* 258 (1959) June (9 pp.)

Factual background of the occurrence of sulfur in British coals. Origin of sulfur in its various forms is briefly discussed and the average contributions of organic and pyritic sulfur to the total sulfur content of coal seams are worked out. A statistical study is made of the average sulfur content of the seams at present worked in all coalfields; the trend of increasing sulfur content in recent years is analyzed and future prospects are briefly outlined. Attention is drawn to important variations of sulfur content with coal rank. The article concludes with brief notes on sulfur in foreign coals and in British crude oil supplies.

Cracking

Cracking of Gaseous Hydrocarbons by Partial Oxidation. E. Bartholomé and H. Nonnenmacher. *Erdöl u. Kohle 12,* 364 (1959) May (6 pp. German text.)

Partial oxidation method is illustrated by three different processes: 1) Homogeneous cracking with controlled quenching for the production of acetylene —size of the burner unit has been increased to a capacity of 14 metric tons of acetylene/day. Other hydrocarbons, ranging from diluted methane to light naphtha, have been investigated as feed; 2) heterogeneous cracking on inert solid materials for the production of olefins—gaseous hydrocarbons premixed with oxygen can be cracked on inert solid materials in an autothermic process for the production of olefins; 3) heterogeneous cracking on catalysts for the production of synthesis gas—gaseous hydrocarbons can be converted into synthesis gas by adding oxygen. This can be done in a flame reaction at the point where hydrocarbon and oxygen meet, followed by a catalytic reaction.

Fundamental Relations of the Pyrolysis of Hydrocarbons to Acetylene and Ethylene. H. Krekeler, R. Wirtz and N. Pechtold. *Erdöl u. Kohle 12,* 353 (1959) May (6 pp. German text.)

Problem has been studied in a high temperature pilot cracking unit. For a given feed material the composition and yield of product gas is dependent primarily on the final reaction temperature attained. Results are practically independent of the temperature of combustion gases from the burner, provided this temperature is not greatly higher than about 2300° C. At burner gas temperatures above 2300° C the C_2 content of the product gas decreases. The energy input to the system is, however, strongly influenced by the burner gas temperature and increases rapidly as the burner gas temperature is decreased. The range of the straight chain saturated hydrocarbons provides the best yields of C_2 gases. Maximum yields of C_2 gases are obtained when the feed stock chain length lies in the range of C_7 to C_{10}.

Ethane

Interaction of Ethane with Oxygen Preadsorbed at Nickel Oxide. W. J. Thomas. *Trans. Faraday Soc. 55,* 624 (1959) Apr. (8 pp.)

Interaction of C_2H_6 with oxygen preadsorbed at NiO shows that the paraffin is adsorbed prior to any surface reaction. Separate experiments on the adsorption of O_2 at NiO confirms that a certain amount of oxygen remains bound to the surface even after high-temperature outgassing. This is important in that the amounts of CO_2 produced by the reaction of C_2H_6 with preadsorbed oxygen appear to be greater than the calculated quantity. The kinetics and energetics of the reactions $C_2H_6 + O(ads)$ are discussed and the results may be useful in interpreting data on the catalytic combustion of hydrocarbons.

Fischer-Tropsch

Fischer-Tropsch Synthesis Mechanism Studies. The Addition of Radioactive Ketene to the Synthesis Gas. G. Blyholder and P. H. Emmett. *J. Phy. Chem. 63,* 962 (1959) June (4 pp.)

When methylene labeled radioactive ketene is added to the extent of 2% of the Fischer-Tropsch synthesis gas being passed over an iron catalyst at 247° and one atmosphere, the hydrocarbon products are found to have approximately a constant radioactivity per mole which is equal to the specific activity of the added ketene. When the synthesis gas with 0.25% ketene is passed over a cobalt catalyst at 185° and one atmosphere pressure the hydrocarbon products have an approximately constant activity per mole which is about one-third the specific activity of the added ketene. The results are interpreted as indicating that due to the large build in of ketene the intermediate complex in Fischer-Tropsch synthesis may resemble an adsorbed ketene molecule. A chain building mechanism is proposed in which the complex is bound to the surface by a metal-oxygen bond as well as a carbon-metal bond.

Observations on the Fischer-Tropsch Synthesis over a Cobalt Catalyst at Low Pressures Using Gas Chromatography. P. W. Darby and C. Kemball. *Trans. Faraday Soc. 55,* 833 (1959) May (9 pp.)

Gas-chromatographic technique has been developed for studying the Fischer-Tropsch synthesis. The apparatus used enabled analyses of the products to be made at various points along the reaction bed as well as at the outlet. Synthesis was studied over a cobalt catalyst using various gas mixtures. It was established that the composition of the products remained appreciably constant along the reactor apart from a tendency for unsaturated products to reenter the reaction. The production of methane was shown to depend on markedly the ratio $(H_2)/(CO)$ in the reacting gases. Although detailed kinetics were not obtained either for the synthesis reaction, i.e., the production of C_2 to C_5 hydrocarbons, or for the formation of carbon dioxide, it was established that both reactions showed similar kinetic behavior and that both were inhibited when there was a high rate of production of methane. The products formed on the desorption of methanol and ethanol from the catalyst were studied in detail. Ethanol gave rise to products, at temperatures above 160° C, which indicated that a synthesis reaction was occurring. The nature of the complex responsible for this reaction is discussed.

Twenty-Five Years of Fischer-Tropsch Synthesis with Fixed-Bed Catalysts. Present Status and Future Possibilities. H. Tramm. *Erdöl u. Kohle 12,* 347 (1959) May (7 pp. German text.)

Within a period of 25 years, 19 Fischer-Tropsch fixed-bed synthesis plants were installed. Most modern plant having gone on stream with full success in South Africa is equipped with reactors having an output capacity which, as compared with original reactors, is 25 times higher. After presentation of the stoichiometrical possibilities of producing hydrocarbons from carbon monoxide and hydrogen, the development of the reactors to the high-efficiency reactor is discussed. The influence of carbon dioxide, steam, and sulfur compounds on the synthesis process is demonstrated and the control of these influences described. A method of calculating the maximum thickness allowed for the catalyst layer is presented.

Gasification

What Does Tonnage Oxygen Cost? S. Katell and J. H. Faber. *Chem. Eng. 66,* 107 (1959) June 29 (4 pp.)

Several processes that can be utilized to convert coal to a synthetic pipeline gas or hydrogen require high-purity oxygen as one of the basic raw materials. Depending on the end product and its specific use, these processes will require oxygen of either 95 or 99.5% purity. In turn, the quantity of oxygen depends on the particular process and the size of the integrated plant. One investigator has reported on the leasing of facilities and compares this approach with the cost of direct purchase of equipment. A critical analysis by management of these alternates is necessary.

Mercaptans

The Gaseous Oxidation of Alkane Thiols. C. F. Cullis and L. C. Roselaar. *Trans. Faraday Soc. 55,* 272 (1959) Feb. (8 pp.)

Gaseous oxidation of ethane and methane thiols has been investigated in the temperature range 210-260° C. In the slow combustion of both compounds, oxygen has a positive influence on the oxidation rate while the thiol has a well-defined retarding effect. Sulfur dioxide is always produced in copious quantities and other products include aldehydes, methanol and carbon monoxide; diakyl disulfides are believed to be formed in oxygen-lean systems. It is suggested that initial oxygen attack occurs at the SH group resulting in the formation of an RS radical. These radicals then are believed either to combine with one another in a chain-terminating reaction or to react with oxygen to form sulfur dioxide and alkyl radicals, which subsequently undergo further oxidation.

Ore Reduction

Fluid Phase Reduction Tests of Pyrite Ash. C. Padovani and G. Salvi. *Rivista dei Combustibili 13,* 270 (1959) Apr. (12 pp. Italian text.)

Gas obtained from the conversion of methane with steam, carbon dioxide or air was employed in fluid phase reduction tests of pyrite ash in order to produce a powder with a high metal iron content for use in reduction processing of organic compounds. By the experiments performed it was possible to determine the best operating conditions, the cheapest type of reducing gas as well as yield and consumption; the reduced powder reactivity can be brought to the required values by heat or mechanical processing. A semi-industrial pyrite ash reduction plant was designed in detail.

Reduction Processes of Iron Oxides in Powder Form. H. Krauch. *Rivista dei Combustibili 13,* 282 (1959) Apr. (11 pp. Italian text.)

Brief report on developments, particularly in America and Russia, in reduction processes of iron oxides in powder form or fluidized. In many semi-commercial plants in operation, low-temperature pressurized hydrogen often is used, as well as methane and carbon monoxide. In view of the good results obtained, the former process appears to be economically promising. When hydrogen is produced electrolytically, the location of an iron-producing plant, if atomic energy is utilized, is only determined by that of the ore deposit and by market conditions, any connection with coal availability having ceased to exist.

Petrochemicals

Sohio Has Shortcut to Acrylonitrile. *Oil Gas J. 57,* 80 (1959) June 22 (2 pp.); **New Acrylo Process for Ohio Standard.** *Petrol. Refiner 38,* 264 (1959) July (3 pp.)

Sohio Research Center (Cleveland) has developed a catalytic vapor-phase, one-step reaction for the production of acrylonitrile. Operation is conducted at temperatures below 900° F and at pressures of less than 3 atm with residence time of only a few seconds. It is highly selective, giving good yields of acrylonitrile and commercially recoverable amounts of valuable byproducts—acetonitrile and hydrogen cyanide.

Producer Gas

Recent Developments in Gas Producers. G. L. Shires. (Reprint by Commonwealth (Australia) Scientific and Industrial Research Organization from *Chem. Eng. and Mining Rev. 50,* (1958) Nos. 11-12 (Aug.-Sept.) (15 pp.)

Two-part discussion covers, in Part 1, fixed bed gasification and examples—fixed bed gas producers, water gas generator, complete gasification plant, Lurgi high-pressure gasifier—and fluidized bed gasification and examples—Winkler fluidized bed process and the Flesch-Demag process. Part 2 includes suspension gasification and examples—Panindco process, Koppers-Totzek gasifier, U.S. Bureau of Mines gasifier, Ruhrgas Vortex gas producer and Rummel cyclone process—and a comparison of gasification systems.

Reformed Gas

Peak Shaving for Natural Gas with LP-Enriched CCR Carrier Gas. R. L. Yeager. *Gas Age 123,* 34 (1959) June 11 (3 pp.)

Objectives of this project, carried out by the United Gas Improvement Co., Phila., are 1) to make a peak shaving gas for natural gas on the Cyclic Catalytic Reforming Gas Set and evaluate the performance of the set; 2) to evaluate the interchangeability of LP-enriched carrier gas with natural gas, and 3) to develop raw materials costs for the purpose of comparison with other types of peak shaving gases. A year's experience with peak shaving via CCR indicates dependability of the equipment. Raw materials costs for enriched gas range from $1.27-$1.65/MCF.

Shale Oil

Thermal Processing of Dictyonema Shale. A. T. Kill and A. A. Elenurm. *Gazovaya Prom.,* 20 (1959) No. 6 (4 pp. Russian text.)

Because of its high ash content, Dictyonema shale, which is found in large quantities in the Estonian Republic, cannot be economically processed in the usual type of equipment. Accordingly pilot plant tests (cap 120 kg/hr) were conducted to thermally process this shale with a solid heat-carrier (ash) at

temperatures of 430-645° C. Reaction residue was burned to provide process heat. Products were tar, gas and ash. Shale analyzed 5% water (as used), 81% ash (dry basis) and 16% organic matter. Maximum tar yield was 21% at 505° C. Gas yield at this temperature was 28 m^3 (6680 kcal/m^3) /metric ton of shale charged. Possible end uses are household gas, LPG, gas suitable for reforming for ammonia synthesis, motor fuel, boiler fuel, fungicides, fertilizers and road composition material.

J. W. Penney

Acetylene

Partial Oxidation Reactor. A. B. Hale (assigned to Union Carbide Corp.) U.S. 2,889,209 (1959) June 2.

Hydrocarbon oxidation burner for acetylene production is described which consists of a vertical mixer dividing to discharge downward through multiple ports to mix and heat the reactants by radial impingement. The parts feed a larger combustion chamber kept alight by a high-velocity burner at the entrance and product gases are rapidly quenched just below by water jets. Dimensions and positioning of parts are fixed to achieve the highest mixing and combustion rate.

Butadiene

Extraction Process for Diolefins Using Copper Ammonium Acetate. D. S. Alexander and W. A. Henry (assigned to Polymer Corp., Ltd.) U.S. 2,887,521 (1959) May 19.

Improved recovery of diolefins from hydrocarbon gases is claimed by use of methanol or ethanol to replace 10 to 30% of the water in the aqueous copper ammonium acetate solvent.

Hydrocarbons

Circulatory Process for Treatment of Hydrocarbons with in Situ Production of Hydrogen. P. S. Viles (assigned to Esso Research and Engineering Co.) U.S. 2,882,216 (1959) Apr 14.

Hydrocarbons are reformed into hydrogen and lighter hydrocarbons in a circulating system in which a first cracking in hydrogen is performed at 500°-1000° F and 15-9000 psig over a cobalt molybdate catalyst. The normally gaseous product then is contacted in a second catalyst zone at 850°-1600° F to form hydrogen, which is used in the first stage. Natural gas may be added to the feed stream.

Hydrogen

Hydrocarbon Conversion Process in the Presence of Hydrogen Produced in the Process. V. E. Henny (assigned to Universal Oil Products Co.) U.S. 2,888,395 (1959) May 26.

In a conversion cracking process for heavy hydrocarbons, an improved combination of cycles for heat economy and reaction control is claimed by use of a fluidized bed catalytic coking cracker with pure hydrogen atmosphere. The coke deposit on the catalyst provides carbon for a water gas generator. Water gas acts to reduce iron oxide to pure iron which, in turn, reacts with steam in fluidized cycle to form hydrogen for the initial coking step.

Methane Separated from Hydrogen Using Ethane as an Absorbent. L. W. Adams. (assigned to Phillips Petroleum Co.) U.S. 2,887,850 (1959) May 26.

Methane is removed from its mixture with hydrogen by contacting the gas mixture at —120° F and 5000 psi with an absorbent such as ethane, ethylene, propane and propylene, fractionating the methane-enriched absorbent to remove methane and recycling the kettle product to contactor.

Ore Reduction

Control Method and Apparatus for Iron Ore Reduction Process. J. W. Halley (assigned to Inland Steel Co.) U.S. 2,889,219 (1959) June 2.

In an iron ore reduction process, improved features of operation are claimed in which reduced and partly reduced ore and gang from the outlet of a shaft reduction furnace are fed by a screw-conveyor to a hearth zone where reduction is completed and melting is achieved by an oxy-coal flame. A thermocouple in the hearth zone controls the rate of feed of material to be melted.

Synthesis Gas

Method for Production of Carbon Monoxide and Hydrogen. D. B. Eastman (assigned to Texaco, Inc.) U.S. 2,892,693 (1959) June 30.

Process for making hydrogen and carbon monoxide from gaseous hydrocarbons is claimed. Process comprises reforming a minor portion of the hydrocarbons with steam in a first reforming zone, reforming an additional part of the hydrocarbons with steam in a second reforming zone, these zones consisting of tubes packed with nickel-alumina catalyst mounted in a heat exchange zone. From the second reforming zone, the CO, CO_2 and unreacted hydrocarbons are mixed with oxygen and reacted at 2000°-3000° F in a partial combustion zone which completes the hydrocarbon conversion. Novelty lies in cooling the outlet gases, first by exchange with the second reforming zone at temperatures above the transition temperature for decarburizing of the steel structure, then cooling with steam to below transition temperature and exchanging heat with first re-

forming zone. The hydrocarbon may be methane and pressures of 100-800 psig are used.

Water Gas

Process for the Generation of Gas in Two or More Producers. W. Flesch and O. Pistorius. U.S. 2,890,107 (1959) June 9.

In a process for generation of water gas, two generators are provided, each initially heated by an oxygen steam downblast of settled bed. Then one generator is "dress" blasted from below by steam to a fluidized state to permit sinking of clinker nodules, while the top gas is passed to the other hot generator where dust and tars are gasified. The "dress" blast then is alternated to the second generator.

8. GAS DISTRIBUTION

Mains

Elgin-Cullen Integration Step by Step. S. R. McCrae. *Gas World 149,* 1188 (1959) June 20 (7 pp.)

Recount of how 23 miles of spun iron main were laid from Elgin, Morayshire, to Cullen, Banffshire, in a conventional manner, the difficulties that were encountered and how they were overcome.

Hydrostatic Testing and Purging of Distribution Lines. S. L. Reynolds. *Am. Gas J. 186,* 17 (1959) July (3 pp.)

Author points out that industry's need is to obtain through testing the guarantee that manufacturing and construction standards are met on distribution lines as they are on transmission lines, but to so reduce testing costs that there will be no temptation to waive requirements in the cases of some of the "little jobs." Case history of Southern California Gas Co.'s program to effect cost reduction and why hydrostatic testing was employed.

Metering

Production Line Methods Applied to Meter Changes. J. Webb. *Gas 35,* 63 (1959) July (4 pp.)

Consolidated Edison Co. (New York) changes approximately 200,000 meters a year. This requires the handling of 1700 meters a day, including the meter to be installed and the meter which has been removed. Production line principles can be applied to the periodic changing of meters because the work is repetitive and routine, and is an operation for continuous daily production. Author describes the system adopted by his company which makes meter maintenance a routine function.

Piping

High Impact PVC—Its Growing Use in Industry. *Corrosion Tech. 6,* 175 (1959) June (4 pp.)

High-impact PVC is ordinary, unplasticized PVC without the degree of brittleness which used to be associated with it. Physical and chemical properties of high-impact PVC piping are outlined in article, followed by a short section describing installation techniques. Market potentials in the water and chemical industries in particular are discussed.

Telemetering

Telemetering and Allocating Natural Gas in Dispatching. V. B. Silliman, Jr. *Gas Age 123,* 25 (1959) June 11 (3 pp.)

Much has been said in recent years regarding the problems of dispatching natural gas. Most references, however, have been in regard to the problems experienced by pipeline companies operating far-flung systems, while relatively few remarks have been directed toward the small distributing companies. With the advent of natural gas into its territories and the active promotion and acceptance of gas for space heating, United Gas Improvement Co., Penn., was faced with the common problem of the most efficient utilization of the available natural gas. Article describes how UGI meets this problem through the operation of its central dispatching unit. Reference is to UGI's upstate properties only. The Philadelphia Gas Works Division operates as a separate entity.

Mains

Pressure-Sealing Coupling for Plain End Pipe. R. E. Risley and F. T. Newell (assigned to Dresser Industries, Inc.) U.S. 2,887,328 (1959) May 19.

Improved self-sealing pipe coupling is claimed which comprises a sleeve or middle ring, at each end of which an integral channel of rectangular cross section is formed. This channel is designed to contain an endless molded rubber ring or gasket. This gasket is molded to a cross section formed by three integral annular flanges projecting inward from a shoulder. When the pipe is forced into the coupling with the gasket in place in the channel, the annular gasket flanges are compressed against the channel and outer pipe surfaces to form flexible pocket seals.

Odorization

Odorization at PGW. K. G. Arpajian. *Gas Age 124,* 26 (1959) July 9 (5 pp.)

Odorization system described is the result of a 10-year study of odorization by Philadelphia Gas Works. It offers, in addition to better odorization

control, the advantages of no handling and loading operations, no accidental spillage as involved in frequent drum handling and no empty drum handling and steaming chores.

9. GAS FUEL UTILIZATION AND APPLIANCES

Air Pollution

Smogless Car Proposed to Fight Smog. *Oil Gas J. 57,* 85 (1959) July 6.

New approach to Los Angeles' critical smog problem was outlined by vice president of Union Oil Co. of California. Five points of evaporation or carbon monoxide losses were covered in Union's experiments. Studies showed 5% of total fuel consumed during idle operations was lost by evaporation through open external vents. Union's conclusion: Vents are unnecessary. "Hot soak" losses, which amount to about 40% of all fuel-system losses from cars in L. A., were cut by 95% with a vacuum-operated system for draining the bowl as soon as the engine is turned off. To overcome fuel-tank vents, Union first installed a ½-in. thick insulation and then plugged the fuel-tank vent with a vacuum-actuated valve. These two modifications cut fuel-tank losses by 90%. An efficient afterburner designed to burn hydrocarbons, carbon monoxide and oxides of nitrogen would solve losses from crankcase vents and clean up exhaust gases.

Burners

Mixers for Burning Gas and Air. D. C. Greenwood. *Product Eng. 30,* 86 (1959) June 22 (2 pp.)

Stability is an important requirement of burners. A stable burner is one that will maintain ignition when cold, and at the pressures and ratios ordinarily used. No burner is considered stable merely because it is equipped with a pilot. Various mixer devices are described and diagrammed.

Flame Research

Infrared Studies of Propellant Flames. H. A. Bent and B. Crawford, Jr. *J. Phys. Chem. 63,* 941 (1959) June (12 pp.)

Application of a fast-scanning infrared spectrometer to the study of the pressure-supported flame of a solid double-base propellant is described. In the region from 700 to 4000 cm^{-1} the flame spectrum in emission contains twelve characteristic bands. With but one exception, these bands correspond to the prominent bands in the absorption spectrum of the quenched products and have been assigned to CO_2, CO, N_2O, H_2O, NO, NO_2, C_2H_2 and HCN. A Rice-Herzfeld type free-radical mechanism appears capable of accounting for the principal features of the thermal decomposition of both nitroglycerine and nitrocellulose. The direct detection of NO_2 is described, and the peculiar role of nitric oxide in nitrate ester flames is pointed out. Some suggestions are forwarded concerning a perplexing, broad and intense absorption at 2600-2700 cm^{-1}.

Industrial Heating

Gas Is Mother to 88,000 Chicks a Year. A. Brown. *Gas World 149,* (Ind. and Comm. Gas Sect.) 114 (1959) June 20 (2 pp.)

Description of author's visit to broiler farm where some 22,000 chicks are housed in two 250-ft long broiler houses. Birds arrive as day-old chicks and go under gas-heated brooders which act as a scientific "mother." After 10 weeks they are ready for marketing.

Town Gas in Modern Foundry Practice. J. Ward. *Gas World 149,* (Ind. and Comm. Gas Sect.) 118 (1959) June 20 (3 pp.)

Highlights of the processes in modern foundry practice where town gas is playing, and can still further play, an important role as a heating medium. In order to appreciate the methods and advantages of using gas as a fuel, brief descriptions of the processes and plant employed are included.

You Can Profit from the Builder's Market. T. H. Quail. *LP-Gas 19,* 23 (1959) July (2 pp.)

Construction industry offers a large potential gallonage market to LPG dealers, but builders must be sold on what LPG can do for them. Expert on how this market should be sold offers some advice.

LPG

Tomorrow's Tomatoes Today—with an Assist from LPG. E. G. Dickson. *Butane-Propane News 21,* 23 (1959) June (4 pp.)

Hydroponics, the science of growing "premium" foods under laboratory conditions, can mean a great deal to the LPG dealer. The hydroponic farmer can earn a livelihood by cultivating an outdoor area small enough to be heated by indoor methods, and in a location ideally suited to the use of LPG. Author describes how one farmer has applied the technique.

Ovens

New All-Gas Bakery Is Highly Automated. A. O. Smith. *Ind. Gas (Amer.) 37,* 15 (1959) June (2 pp.)

Single lap, 44-tray Petersen gas-fired bread oven at Jewel Tea Co.'s bakery in Melrose Park, Ill., is

automatically discharged; baked bread is automatically depanned and then cooled before automatic slicing. Continuous gas-fired ovens for bread and buns, plus the gas-fired donut fryer, contribute to the efficiency and speed by which the baked products go through in the shortest possible time with a consequent reduction in production costs.

Burners

Burners. J. R. Williams and C. A. McFadden (assigned to Selas Corp. of America.) U.S. 2,888,980 (1959) June 2.

Torch type gas burner is described in which the fuel passes through a drilled ceramic distributor, and also through flutings on the cylindrical distributor surface, said distributor being threaded to fit within the burner body, and recessed to form a flared cylindrical forward chamber, which, in turn, forms a flame of large section.

Methods and Means Relating to High Capacity Forced Draft Gas Burner Art. T. S. Voorheis. U.S. 2,889,871 (1959) June 9.

In a high capacity forced draft burner using low pressure gas, improved mixing and flame propagation are achieved by introducing the gas through two concentrically mounted rings, while forced air is introduced in two counterrotating streams and an outer non-swirling stream. Controlling gas valves, air shutters and linkages are provided.

Process and Apparatus for Utilizing Submerged Combustion. R. V. Heinze (assigned to Submerged Combustion Co. of America, Inc.) U.S. 2,890,166 (1959) June 9.

Apparatus is claimed for heating a body of liquid with a submerged combustion burner in a closed first vessel, overflowing the liquid into a second vessel where incondensable gases evolve and are removed. The liquid then is passed to a third closed vessel where condensable gases (steam) are evolved and the liquid is returned to the first vessel for further concentration. Oils and chemicals also may be processed in this apparatus.

Dryers

Drier Lint Collector. J. P. Flannery (assigned to The Murray Corp. of America.) U.S. 2,886,900 (1959) May 19.

Improved lint collector for a clothes dryer is claimed in which a lint screen of cylindrical form is placed in the lint-laden stream of air. The lint is removed as the air flows radially through the screen to an outer housing, and a rotary helical or spiral bladed wiper continuously removes lint from the screen and delivers it axially to an end compartment where it may be compacted.

Water Heaters

Gas Water Heater. S. H. Thompson (assigned to Continental Water Heater Co.) U.S. 2,888,911 (1959) June 2.

Improved table top water heater consists of a housing containing an insulated boiler tank in which the burner and combustion chamber are enclosed. Waste gas flues rise from the burner chamber to a cross flue diametrically sealed across the top space of the boiler, said flue forming a telescoping sealed connection with the ventilating flue as well as a downdraft protector.

10. EQUIPMENT AND INSTRUMENTATION

Calorimeter

Installing and Testing Recording Calorimeters. S. M. Keehn. *Gas 35,* 122 (1959) July (5 pp.)

Cutler Hammer AB recording calorimeter is capable of an accuracy of better than one-half of one per cent under controlled conditions, but in reaching for this high precision the extent that conditions surrounding the calorimeter can be allowed to vary must be controlled. Discussion of the operating characteristics of the Type AB calorimeter, a piece of equipment that is widely used throughout the gas industry.

Computers

Computer Keeps Tabs on Profits. L. A. Whitney. *Oil Gas J. 57,* 110 (1959) July 6 (5 pp.)

Actual solution of figuring optimum profit developed by Champlin Oil & Refining Co. is completely unpretentious. It involves three major steps: 1) A complete material accounting based on crude run; 2) development of the minimum cost of operations for specified conditions together with detailed unit cost of all products, and 3) computation of the total gross margin as well as individual product margins.

Computer Solves Problem of Material and Economic Balance. R. Landes and E. Walker. *Oil Gas J. 57,* 117 (1959) July 6 (5 pp.)

To correctly evaluate an operating change, Champlin Oil & Refining Co. was required to make a complete material and economic balance over the entire refinery. This presented a problem which could be solved manually, but the time factor was prohibitive. When management asked for economic evaluation to cover certain possible operating conditions, answers were needed immediately for making decisions.

After selecting the machine (Alwac computer) work on the initial problem was initiated. The economic and plant-balances portion of the proposed problem was approached on the conventional basis. Fixed and variable costs as well as unit material balances were developed around each cost center. These factors were then accumulated for the over-all plant balances.

Relatively Simple Analog Computer Facilitates Rapid Calculations of Complete Analysis of Vapor Phase Chromatogram. R. H. Muller. *Anal. Chem. 31,* 67A (1959) July (2 pp.)

Podbielniak Computagram is a relatively simple analog computer which makes it possible to calculate a complete analysis of a vapor phase chromatogram in less than 3 minutes. The component fractions are accurate to 0.1%. Peak areas or peak heights are corrected by the computer for differences in the response of the detector and the computer normalizes the corrected areas or heights to total 100, thereby giving the per cent (mole or weight according to correction factors inserted) of each individual component.

The Use of Digital Computers for Petroleum and Refining Engineering Problems. R. J. Baxter. New York: ASME Paper No. 58—Pet-24, 1958; $.80 ($.40 to members.); **The Computer at Work.** *Mech. Eng. 81,* 54 (1959) June (2 pp.)

Introduction of electronic computers has contributed greatly to the rapid growth of operations research type of work. This so-called scientific approach to management decision-making, which by and large uses various mathematical analysis techniques, has in many cases justified the use of computers. It is only necessary to give several days' special training to any qualified engineer to enable him to use the IBM 650 IT compiler or the large 704 Fortran coding systems. All other machines have comparable compilers or machine shorthand-programming systems. There is significant work being done to adopt universal "language" whereby any type or make of computer will be able to handle properly written instructions in a new, universal shorthand or language. Author includes nine pages listing engineering applications of the electronic computer in the petroleum industry.

Conveyors

The Flow of Granular Solids Through Orifices. R. T. Fowler and J. R. Glastonbury. *Chem. Eng. Sci. 10,* 150 (1959) No. 3 (7 pp.)

Factors affecting the flow of granular solids through orifices of different diameter and shapes under gravity conditions has been investigated at various heads. Different granular materials such as sand, sugar, rape seed, wheat and rice were used and the best equation was determined. The effect of head and container diameter was found to be insignificant in the 347 runs used in the statistical analysis. The equation used allows the prediction of flow rates through various orifices with an over-all accuracy of ±10%.

Corrosion

A Constant Temperature Corrosion Probe. K. W. Kear. *J. Inst. Fuel 32,* 267 (1959) June (12 pp.)

Simple corrosion probe capable of operating at constant temperatures for long test periods with a minimum of service or attention is described. Other techniques available for assessing flue gas corrosion are reviewed and the present has been designed in an effort to overcome many of the inherent limitations and disadvantages of these methods. This is followed by a description of the development, design and operation of the probe. Article concludes with a few results and a discussion to illustrate the scope of the instrument for use in full-scale boiler and laboratory-scale investigations.

Gas Turbines

Combustion Studies in a Transpiration-Cooled Gas-Turbine Combustion Chamber. B. V. Poulston. *J. Inst. Fuel 32,* 279 (1959) June (9 pp.)

Principles of effusion cooling have been applied to a practical industrial gas turbine combustion chamber in the form of the "louvred" wall construction. A research combustion chamber of this kind and the apparatus and techniques used for studying its performance are described. Chamber incorporates a swirler/shroud flame stabilizer and simplex pressure-jet atomizers. After considering the general combustion characteristics of this type of stabilizer, the research results are discussed from the point of view of discovering the precise effect of the air which passes through the "louvred" walls. This air, in addition to cooling the walls, mixes with the air surrounding the flame and influences combustion. Effect depends upon the relative air quantities and velocities. Conditions can be such that there is little turbulence on the periphery of the flame and combustion quality may suffer.

Don't Waste that Gas-Turbine Heat. I. G. Rice. *Oil Gas J. 57,* 66 (1959) June 29 (5 pp.)

Gas turbine is part turbine, part boiler and the rest a hot-air generator. To take full advantage of the gas turbine, an understanding of these qualities is required. Power, the first of its features, is obtained directly from the air, thus incorporating the functions of the boiler and the steam cycle within itself. Another peculiarity is its ability to provide large

quantities of highly preheated air. This gas in combination with a fuel for supplementary firing can operate a waste-heat boiler and the waste-heat boiler can be cascaded with a fired boiler. Description of such heat recovery systems as well as a brief description of gas-turbine operation itself.

Instruments

Measurement for Control. J. C. Hogg. *Gas World 149,* 1184 (1959) June 20 (5 pp.)

Article is limited to measurements which are primarily for process or plant control; devices which provide information in quantitative or qualitative form on which immediate action can be taken, either manually or automatically. It is understood that many of these can also provide data for administrative and cost control. Reference is mainly to devices which detect or obtain the measurement, i.e. the measuring elements rather than the associated mechanism which makes use of the information by indicating, recording, integrating, processing, computing, etc. Measuring elements are the core of the instrument, and these are the features in which the gas engineer must put his trust or reject.

Pumps

Cavitation and NPSH Requirements of Various Liquids. V. Salemann. *J. Basic Eng. 81,* 167 (1959) June (7 pp.)

Test results on the net positive suction head, NPSH, requirements for centrifugal pumps handling water up to 420° F, some hydrocarbons, and Freon-11 are presented. Satisfactory pump performance was observed with net positive suction heads less than those required by the pump on cold water. A direct measurement of NPSH was attempted and is reported. The cavitation process is discussed and a correlation and method of prediction for all liquids is proposed.

Radioactivity Applications

Using Isotopes to Measure Low Pressures. G. F. Vanderschmidt. *Electronics 32,* 60 (1959) June 19 (2 pp.)

Radiological vacuum gages permit measuring extremely low pressures for checking industrial and scientific laboratory equipment and in high-altitude research. This instrument is extremely compact and provides a digital output that can be used for storage or telemetering.

Temperature Measurement

Resistance Thermometer Spear for Field Measurement. A. C. Jason and A. Lees. *J. Sci. Instruments 36,* 272 (1959) June (3 pp.)

Instrument described measures temperatures in the range —30° to 70° F, with an accuracy of ±0.2° F. Sensitive portion consists of a copper wire spiral enclosed in a length of hypodermic tubing; the resistance is measured on a Wheatstone bridge. The instrument is inexpensive, reliable, robust and self-contained.

11. MATERIALS OF CONSTRUCTION, AND CORROSION

Coatings

Aluminizing Resists Refinery Corrosion. C. F. Tisinai and C. H. Samans. *Petrol. Refiner 38,* 153 (1959) June (8 pp.); **Aluminizing Resists Refinery Sulfidation and Oxidation.** *Petrol. Eng. 31,* C-20 (1959) June (5 pp.)

Sulfide corrosion can occur in reforming and hydrogenation units as well as cokers and pipe stills. As-sprayed coatings have not always been successful in overcoming this type of corrosion. To improve the effectiveness of aluminum coatings, limited work has been performed on diffusion heat treatment of such sprayed equipment in the field. For dipped coatings, several different procedures are used, some of which are patented. In a typical procedure, the parts are preheated in the presence of a molten flux and then dipped into a molten bath of aluminum whose impurity content is controlled to a limited extent. Technique of spraying aluminum on steel surfaces requires careful surface preparation to obtain a good mechanical adherence of the aluminum to the steel. Although much experience has now been obtained by some spraying companies, there are newcomers who are spraying coatings for particular applications who may not be completely aware of all of the precautions required.

Performance of Organic Coatings in Tropical Environments. A. L. Alexander, B. W. Forgeson and C. R. Southwell. *Corrosion 15,* 291t (1959) June (4 pp.)

Seven-, six-, three- and one-year exposures have provided quantitative data on the ability of organic coating systems to protect metals from the fire corrosion environments characteristic of tropical latitudes. Data are reported on the performance of more than 350 coating systems in which alkyds, epoxys, synthetic rubbers, phenolics, vinyls and bitumens were used singly or in combinations and mixtures.

Superior Gas Plant Features Color. *Petrol. Refiner 38,* 268 (1959) June (2 pp.)

Superior Oil Co.'s gas processing plant uses aluminum with a baked enamel jacketing in soft pastel

colors for insulation purposes. New plant is among the largest in Southern Louisiana and is capable of processing over 300 MMCF/day. Design utilizes refrigerated absorption with dehydration accomplished by glycol injection into the gas being chilled.

Wash Primer Development and Characteristics. L. R. Whiting. *Corrosion 15,* 311t (1959) June (4 pp.)

Development, characteristics and properties of wash primers are explained. Data are given on wash primers principally because of their efficiency and wide use. Reactive and non-reactive types resulted from efforts to understand better the reactions involved and as a result of efforts to produce a one-package system. Reacted wash primers are produced by reacting phosphoric acid and chromium oxide in a solution of butyral resin at high temperature, producing a clear green lacquer. Non-reactive primers are prepared by dispersing chromates of lead, strontium and barium in a solution of butyral resin, and then adding phosphoric acid. A stable wash primer was prepared by dispersing chromic phosphate in a solution of PVB.

Corrosion

Factors Affecting the Corrosion of Steel by Oil-Brine-Hydrogen Sulfide Mixtures. D. W. Shannon and J. E. Boggs. *Corrosion 15,* 299t (1959) June (4 pp.)

Study was conducted of factors affecting the corrosion of steel by oil-brine-H_2S mixtures in order to determine what conditions need to be met in setting up a screening test procedure for possible corrosion inhibitors. Initial rate of corrosion is dependent on the concentration of H_2S. After the first day, the reaction becomes diffusion-controlled and is independent of H_2S concentration over a wide range. At very high H_2S concentrations, the corrosion rate actually decreases because of a change in the nature of the FeS coating formed on the steel. Presence of sodium chloride prevents the formation of a protective FeS coating on steel, and the corrosion rate increases with increasing salt concentration, reaching a maximum at about 1% salt. Above this concentration, the rate decreases, possibly due to inhibition by the salt itself.

Graphite

Graphite Cloth — Flexible Form of Familiar Material. *Chem. Processing 22,* 52 (1959) July (2 pp.)

Graphite, long a standard in processing equipment where high chemical and thermal resistance are required, now is available in a form that promises to extend its use potential manyfold. In flexible form, graphite holds promise as a reinforcing agent for various plastics and refractory materials used at high temperatures, or where thermal cycling is required. It is a potentially useful raw material for bag type filters for hot non-oxidizing gases; for equipment to handle corrosive fluids; for electrostatic precipitators.

Inhibitors

An Analytical Procedure for Testing the Effectiveness of Hydrogen Sulfide Corrosion Inhibitors. D. W. Shannon and J. E. Boggs. *Corrosion 15,* 303t (1959) June (4 pp.)

New method is proposed as a standard screening test for possible hydrogen sulfide corrosion inhibitors. This is a dynamic, weight-loss method which attempts to control conditions sufficiently well that substances which offer promise of being effective inhibitors under field conditions can be selected for further study. The test is inexpensive and simple, so that it can be performed economically by a relatively untrained technician on large numbers of materials. Method is described and reasons for selecting the particular conditions are explained. Then illustrations of the application of the procedure to a number of types of inhibiting substances are presented.

Acetylenic Corrosion Inhibitors. G. L. Foster, B.D. Oakes and C. H. Kucera. *Ind. Eng. Chem. 51,* 825 (1959) July (4 pp.)

As oil wells are drilled deeper and higher temperatures are encountered, inhibitors to prevent corrosion of oil well casing and tubing during acidizing have become more important. Acetylenic compounds are effective inhibitors. In this study, propargyl alcohol was selected as a standard inhibitor, its structure was altered systematically, and the resulting compounds were evaluated as acid inhibitors. The triple bond was found to be the focal point of the inhibition. Substituent groups in the molecule affect their basicity and modify their ability to inhibit. The explanation of these trends provides a new research tool for the study of the mechanism of acid corrosion inhibition. This field holds promise of an additional market for acetylenic chemicals.

Screening Inhibitors for Prevention of Water Flood Corrosion. C. C. Wright. *Corrosion 15,* 97 (1959) July (3 pp.)

Method for screening water flood corrosion inhibitors which uses the actual field system is proposed. Method uses two plastic cells in series with chemical injection made at the exit of the first plastic cell. There were 25 feet of garden hose between the two blocks. Coupons and electrical resistance probes

were used to determine the effect of the inhibitor. Good correlation was obtained between the screening test and a field trial of the same inhibitor.

12. ANALYTICAL METHODS AND TESTS

Analytical Instruments

Selecting Analytical Instruments for Process Applications. G. S. Turner. *Instruments and Control Systems 32,* 904 (1959) June (3 pp.)

Process analyzers can be divided into two general classes — single- and multi-component analyzers. Single-component category includes optical-type analyzers (infrared, ultraviolet and flow colorimeter), refractive index and dielectric constant analyzers, *p*H, oxygen and water analyzers. Multi-component analyzers include the mass spectrometer and gas chromatograph. Multi-component analyzers can be used for single-component determinations, and at least one of the infrared analyzers can be engineered for two-component analysis. By and large when two components are required, both types should be considered. Article presents the features of each type of analyzer.

Stream Analyzers—A Continuous Approach to Improving Control. D. J. Fraade. **Part 1.** *Gas 35,* 73 (1959) June (3 pp.); **Part 2.** *Ibid.,* 74 (1959) July (4 pp.)

Author begins his series on some of the more commonly used types of continuous process stream analyzers applicable to the natural gas industry with a discussion of moisture monitoring equipment and the Titrilog. Applications of gas chromatography and the mass spectrometer are the subjects of Part 2.

Carbon Determination

Carbon and Hydrogen Microdetermination by Automatic Combustion Control. E. Stehr. *Anal. Chem. 31,* 1274 (1959) July (5 pp.)

Automatic method for the microdetermination of carbon and hydrogen is described in which the rate of combustion is accurately controlled by the changes in pressure which develop in the combustion tube from the vaporization and burning of the sample. By use of a diaphragm-type pressure switch, movement of the sample heater is stopped when the pressure rises above an equilibrium pressure established by a choking plug; when the pressure again drops to the equilibrium point, motion of the heater is resumed. Thus, a uniform cycle of combustion is automatically effected for samples ranging from solids to volatile liquids. Improvements in the apparatus include a new pressure regulator and flowmeter for the oxygen gas, a precision mortar, and a grooved track for adjusting the position of the separate units in the train.

Chromatography

Analysis of Hydrocarbons in Well Site Drilling Mud. H. R. Chism, W. Scott and R. A. Karas. *World Oil 148,* 138 (1959) June (3 pp.)

Gas chromatograph unit which permits rapid and accurate analysis of hydrocarbons in the drilling mud at the well site is being used successfully in the U.S. and in foreign fields. Principle behind the technique is to minimize the passing up of possible productive zones. Detection and measurement of gases released at the surface provides the geologist with vital information for evaluating potential producing zones and enables him to determine the feasibility of a drill stem or production test. Technique can also be applied in comparing new productive zone conditions with those in established oil and gas fields.

Gas Chromatograph. Ionization by Alpha-Particles for Detection of the Gaseous Components in the Effluent from a Flow Reactor. W. M. Graven. *Anal. Chem. 31,* 1197 (1959) July (3 pp.)

Inexpensive detector is constructed for analysis of the effluent from a continuous flow reactor. Gas absorption columns of molecular sieves are employed using ionization current produced by alpha particles. Detector is not influenced by changes in temperature or by rate of gas flow.

Gas Chromatography. Effect of Sample Size on Height of Equivalent Theoretical Plate and Retention Volume. R. M. Bethea and M. Smutz. *Anal. Chem. 31,* 1211 (1959) July (4 pp.)

Research was conducted to determine the importance of sample size on the performance of gas chromatography columns at low flow rates. Minimum value of HETP was found when a 4- to 7-μl. liquid sample was used for an alochol test mixture in a dibutyl phthalate column. Minimum HETP values for the same mixture in a dibutyl sebacate column occurred at a sample size of 10 to 12μl. and also when an ester test mixture was used on the same two columns. Minimum values of retention time with sample size were obtained for all systems tested. Optimum values of sample size exist for some feed systems in certain substrates at low flow rates. This may aid other research workers in obtaining maximum resolution of mixtures.

Gas and Liquid Elution Chromatography. Quantitative Detector Evaluation. H. W. Johnson, Jr. and F. H. Stross. *Anal. Chem. 31,* 1206 (1959) July (6 pp.)

Specific procedure is outlined for the evaluation of detectors used in gas and liquid chromatography. Main interest deals with the smallest amount of sample that can be determined reliably by a detector. Noise is measured at various frequencies and treated statistically as a definition of detector limitations.

Dust Determination

Dust in Gas Streams. Part 4. Theory and Operation of the A.G.A. Light Scattering Photometer. A. W. Doyle, J. R. Ehrenfeld and N. W. Wiederhorn. *Am. Gas J. 186,* 27 (1959) July (5 pp.)

Light scattering by suspended particles has been understood for many years. When a particle is illuminated by a beam of light, the particle scatters a portion of the incident light in all directions. Scattering is dependent upon the size of the particle, the wavelength of the incident light, the refractive index of the particle relative to the medium in which it is suspended and the angle of observation. As the size of the particle increases, the relations for scattering become very complex. Two forward-angle-scattering photometers have been developed for the purpose of monitoring suspensoids in gas distribution and transmission systems. One will operate at pressures up to 250 psig, the other to 1500 psi. For small particles there is very little to choose from with regard to a preferred angle of observation. However, since for larger particles a greater portion of the scattered light is in the forward direction, greater sensitivity can be achieved by the observation of the scattered radiation at small angles from the incident beam. Description of the high pressure instrument and report of its performance with liquid particles suspended in the gas stream.

Infrared Spectroscopy

Microgas Cell for Infrared Spectroscopy. J. U. White, N. L. Alpert, W. M. Ward and W. S. Gallaway. *Anal. Chem. 31,* 1267 (1959) July (4 pp.)

For analysis of small gas samples, a microgas cell is constructed and incorporated into a Beckman IR-5 infrared spectrophotometer. Its path length is one meter, its volume is 22 ml. Transmittance through it and the beam condenser is 30%.

Mass Spectrometer

Mass Spectrometric Analysis. Spectral Data File Utilizing Machine Filing and Manual Searching. F. W. McLafferty and R. S. Gohlke. *Anal. Chem. 31,* 1160 (1959) July (4 pp.)

New filing system for mass spectra utilizes the unique advantages of the mass spectrometer in mixture identification. No machine searching of this file is necessary because all spectra having one of the 15 most significant peaks at a particular m/e ratio (mass to charge ratio) will be grouped together in probable order of abundance. Each such filed card also shows these significant peaks in order of abundance, making reference to original spectra unnecessary. Original filing of this large amount of data can be accomplished with modern business machines. A second no-band filing system is described.

Oxygen Determination

The Galvanic Cell Oxygen Analyzer. W. J. Baker, J. F. Combs, T. L. Zinn, A. W. Wotring and R. F. Wall. *Ind. Eng. Chem. 51,* 727 (1959) June (4 pp.)

Process analyzer for traces of oxygen in petrochemical plant streams is based on the electrochemical reduction of oxygen in a silver-lead galvanic couple. The analyzer is little affected by operating variables and has given ppm oxygen analyses with excellent reliability and minimum maintenance.

Radioactivity Applications

The Action of ^{60}Co γ-Radiation on Aqueous Solutions of Acetylene. P. G. Clay, G. A. R. Johnson and J. Weiss. *J. Phys. Chem. 63,* 862 (1959) June (5 pp.)

Cobalt-60 γ-irradiation of water saturated with acetylene (1 atm) in the absence of oxygen yielded C_1, C_2 and C_4-aldehydes and a white solid polymer. The irradiated solution showed a very strong, broad absorption band with a maximum at about 200 mμ. Aqueous solutions of acetylene-oxygen mixtures, on irradiation, yielded glyoxal and hydrogen peroxide, with small amounts of an organic hydroperoxide ($G \sim 0.3$). The formation of the radiation products has been studied at different ratios of oxygen/acetylene, as a function of pH and in the presence of added ferrous sulfate. Under certain conditions, glyoxal is apparently formed by a chain reaction.

Chemical Effects of Low Energy Electrons. R. R. Williams, Jr. *J. Phys. Chem. 63,* 776 (1959) June (5 pp.)

New technique has been developed for the study of chemical decomposition of gases by low energy electrons. Ultraviolet light falling on a silver surface generates photoelectrons which are accelerated in the gas by application of an electric field. The electron yields of products formed by irradiation of methane and ethane have been examined as a function of applied potential and the behavior of the systems suggests that an important primary process is non-ionizing excitation by electron impact. Little can be said at present about the nature of the products of these reactions other than to note that they correspond, qualitatively, to those obtained in radiolysis reactions. It is difficult to conceive of a radical

reaction which could produce a product such as isopentane from methane at room temperature. The possibility remains that ionic reactions may contribute some small part of the total product yield and may be primarily responsible for such a product. Further investigation to examine this and other aspects of the problem has been initiated.

Ion-Molecule Reactions of 1,3-Butadiene, of Acetylene and of Acetylene-Methane Mixtures. R. Barker, W. H. Hamill and R. R. Williams, Jr. *J. Phys. Chem. 63,* 825 (1959) June (4 pp.)

Reactions with molecules of positive ions formed in the electron bombardment of 1,3-butadiene, of acetylene and of acetylene-methane mixtures in the ionization chamber of the mass spectrometer have been investigated. Appearance potentials of the more important primary ions of 1,3-butadiene have been measured as well as the appearance potentials of all secondary ions. The heats and cross sections of ion-molecule reactions have been calculated.

Monitoring Radioisotope Tracers in Industry. F. E. Armstrong and E. A. Pavelka. *Electronics 32,* 42 (1959) June 26 (2 pp.)

Application of radioactive isotopes as tracers in the petroleum industry often involves monitoring the radioactivity level of flowing liquids or gases over relatively long periods of time. In many instances, location of monitoring points is such that reliable power is not available. Often no housing is available for monitoring instrument and it is subjected to wide extremes of temperature and humidity. Proximity of heavy moving machinery may impose severe shock and vibration problems. As operation by untrained personnel is an occasional necessity, a minimum of controls or adjustments is desirable. Instrument described was designed for field use under such conditions.

Thermal Analysis

Derivative Thermoanalytical Techniques. Instrumentation and Applications to Thermogravimetry and Differential Thermal Analysis. C. Campbell, S. Gordon and C. L. Smith. *Anal. Chem. 31,* 1188 (1959) July (4 pp.)

Thermoanalytical techniques provide continuously recorded curves that characterize a system in terms of the variations in its thermodynamic properties and reaction kinetics as a function of temperature. To define these thermal spectra more exactly and interpret the phenomena and reactions involved, particularly in overlapping temperature regions, a technique has been developed for simultaneously obtaining a continuous record of the derivative for the thermogram. A simply constructed differentiator consists of a battery energized precision transmitting potentiometer coupled to the balancing slide-wire of the recorder used to obtain the primary thermogram. The signal generated by the transmitter circuit is differentiated by a resistance-capacity circuit and recorded on another time-base or *x-y* potentiometric recorder.

Sulfur Method

Apparatus for Quantitative Determination of Sulfur. W. K. Aites (assigned to Lindberg Engineering Co.) U.S. 2,888,332 (1959) May 26.

Apparatus for improved determination of sulfur content consists of a crucible for holding the sample, a combustion tube enclosing said crucible with means for oxygen flow through the tube and a high-frequency coil surrounding the combustion tube at the position of the crucible and in the space above the crucible. A tube connects the combustion zone with an absorbent system for holding the oxidized sulfur with a secondary heater of porous ceramic just above the crucible with a conductive wire coil therein to heat by high-frequency induction and aid in oxidation.

13. BASIC SCIENCE

Equation of State

An Improved Equation of State for Gases. J. J. Martin, R. M. Kapoor and N. de Nevers. *A.I. Ch.E. J. 5,* 159 (1959) June (2 pp)

Based on properties which are characteristic of all gases, modifications are developed for an equation of state previously proposed. A specific application of the modified equation is made for the PVT data on carbon dioxide, and considerable improvement over the original equation is shown for densities in the neighborhood of 1.4 times the critical density. The new equation differs from the old equation only by the presence of the A_5 and C_5 terms, these having originally been taken to be zero.

Reduced Density Correlation for Hydrogen: Liquid and Gaseous States. C. A. Schaefer and G. Thodos. *A.I.Ch.E. J. 5,* 155 (1959) June (4 pp)

Available experimental density data for hydrogen have been compiled to produce a reduced density correlation for the liquid and gaseous states. This investigation utilized 57 sources of data, extending from 1880 to 1954. Based on the concept of a reduced density, a correlation for hydrogen has been developed ranging in temperature from the melting point (14° K) to 3300° K and in pressure as high as 2550 atm. This correlation provides continuity

between the liquid and gaseous phases, whereas existing equations of state fail to describe the experimental behavior in the transitional region, particularly near the critical point. A total of 485 experimental points covering the entire region were checked to establish the reliability of this correlation, which reproduced the experimental data to within 0.49%.

On the Second Virial Coefficient. M. L. Goldberger. *Phys. of Fluids 2,* 252 (1959) May-June (4 pp.)

Second virial coefficient is calculated by a new method which exploits certain results known from formal scattering theory. In particular it is shown that the essential quantity may be expressed as the determinant of the *S* matrix at a given energy. Present approach suggests several approximation techniques and also seems applicable to many-body problems.

Ethylene

High Resolution Raman Spectroscopy of Gases. Part 12. Rotational Spectra of C_2H_4 and C_2D_4 and the Structure of the Ethylene Molecule. J. M. Dowling and B. P. Stoicheff. *Can. J. Phys. 37,* 703 (1959) June (20 pp.)

Pure rotational Raman spectra of C_2H_4 and C_2D_4 were photographed in the second order of a 21-ft grating. Resolution achieved was such that several lines due to single transitions were observed (and identified) in the spectra of both molecules. An analysis of these lines based on the non-rigid asymmetric top yielded rotational constants for the ground states. The structural parameters from these constants are in agreement with the recent preliminary results of the electron diffraction data. There also is agreement between these values and those obtained from a recent study of the rotation-vibration spectra of C_2H_4 and C_2D_4, although the agreement between the ground state rotational constants is not as satisfactory.

Fluid Flow

Fluid Flow Rules Unit Operations. J. Coates and B. S. Pressburg. *Chem. Eng. 66,* 185 (1959) June 15 (6 pp.)

Most unit operations are rate phenomena. These operations differ, primarily, in the nature of the driving potential and of resistance to flow. Density, pipe size, flow velocity as well as viscosity and pipe roughness affect pipeline friction and, hence, govern flow rate in process equipment.

A Radioactive Tracer Technique for Particle Velocity Measurement in Solids-Gas Systems. W. H. Gauvin, I. S. Pasternak, L. B. Torobin and L. Yaffe. *Can. J. Chem. Eng. 37,* 95 (1959) June (4 pp)

To record the velocity history of a particle in complex problems of solid-gas flow with greater accuracy than is possible with existing methods, a technique was developed which in essence consists of following the flight of the particle under test — which has been previously tagged with a suitable gamma-emitting nuclide — by means of Geiger probes placed at predetermined points along the outside surface of the duct or reactor and parallel to its axis. Sharp timing pulses are thus obtained on the screen of a cathode-ray oscilloscope, which permit the estimation of the time elapsed between probe stations to less than 1/1000 second. Complete description of the electronic aspects of the method is given, and details of the particle preparation are outlined.

For Turbulent Flow . . . Graphic Method Speeds Line Sizing. K. S. McMahon and J. C. Webb. *Petrol. Eng. 31,* C-10 (1959) June (7 pp.)

Sizing process lines during plant design is generally considered a chore. Because the cost of a process and utility piping system usually accounts for 5-15% of the total capital cost, this chore is a very important phase of plant design. Authors present an alignment method for sizing lines in turbulent flow that will greatly reduce the calculation time required while retaining accuracy. Chart included is patterned after a similar "line loss" chart developed at the former Standard Oil Development Co. Formulas and physical property correlations have been changed to improve both range and flexibility. Chart formulas and fluid property correlations are believed to be improvements over similar ones used in other alignment charts.

Fractionation

Figure Distillation This New Way. W. N. Lyster, S. L. Sullivan, Jr., D. S. Billingsley and C. D. Holland. **Part 1. New Convergence Method Will Handle Many Cases.** *Petrol. Refiner 38,* 221 (1959) June (10 pp.)

Multicomponent distillation calculations on a digital computer require all judgments and decisions to be stated beforehand. Furthermore, most computer methods use a series of successive approximations, and some means is needed to make successive results converge quickly to the answer. Series of articles proposes a simple convergence method which causes a rapid approach to the desired solution. More than 50 different examples have been solved, including a wide variety of feeds and number of plates. Solutions for several have been obtained independently from a medium-scale and a large-scale digital computer. Method is readily applied and

appears to be adequate in view of the success with which it has been used.

Heat Transfer

Direct-Contact Interstage Cooling . . . What Are Its Possibilities? W. S. Stewart and R. L. Huntington. *Oil Gas J. 57,* 96 (1959) July 6 (6 pp.)

Cooling of gases by direct contact with liquids has large-scale industrial applications, most of which use wetted-wall, packed and spray towers. From the results of a recent experimental study at the University of Oklahoma, it appears that direct cooling would save $24,000/MSCF/hr for compressor investment alone figured at $300/hp. Work was undertaken to obtain values for heat and mass transfer coefficients for a 6-in. by 10-ft perforated-plate column when operated as a direct-contact cooler and to determine the effect of the four variables—liquid flow rate, gas flow rate, gas temperature (140°-240°F inlet), and column pressure (1-5 atm) on heat and mass transfer coefficients. Values for the over-all heat transfer coefficient, gas film heat transfer coefficient, liquid film heat transfer coefficient, and over-all or gas film mass transfer coefficient have been calculated from the experimental data.

The Effect of a Nonisothermal Free Stream on Boundary-Layer Heat Transfer. E. M. Sparrow and J. L. Gregg. *J. Appl. Mech. 81,* 161 (1959) June (5 pp.)

Analysis is conducted for laminar forced-convection heat transfer from a flat plate to a nonisothermal free stream. An exact solution of the boundary layer energy equation is found for the situation of linearly varying free stream temperature. Numerical calculations are carried out for Prandtl numbers in the range $0.01 \leq Pr \leq 50$. Results are presented for the change in heat transfer due to the variation in free-stream temperature. This effect decreases with increasing Prandtl number.

Heat of Vaporization

Correlating Latent Heats and Entropies of Vaporization with Temperature. D. F. Othmer and D. Zudkevitch. *Ind. Eng. Chem. 51,* 791 (1959) June (6 pp.)

These important functions are essential in process and plant design. Entropies come from latent heats, on which there are few experimental values. Use of entropies of vaporization aids many calculations, but they are published only for a few fluids used in power generation or refrigeration. Convenience of their use is seldom possible. By correcting for nonideality of the gas and the compressibility of the liquid, new equations and nomograms were developed thermodynamically. Latent heats and entropies of vaporization may be immediately evaluated with an accuracy comparable to that from calorimetric measurements for some 500 compounds from the equations and simply used nomograms. Ready methods of applying to other compounds are given.

High Pressures

Ultra High Pressure for Materials Research. C. M. Schwartz and W. B. Wilson. *Battelle Tech. Rev. 8* 3 (1959) June (6 pp.)

Authors described techniques for achieving unusual combinations of extreme pressures and high temperatures that open new vistas of materials development. Such methods, they believe, will contribute significantly in the search for the materials being sought. The Bridgman anvil, tetrahedral die and "belt" die are briefly discussed.

Mass Transfer

Elementary Processes of Mass Transfer in Extraction, Absorption and Distillation. H. Kroepelin, H.-J. Neumann and E. Prött. *Erdöl u. Kohle 12,* 344 (1959) May (4 pp. German text.)

Mass transfer was studied on individual droplets in liquid/liquid extraction. It was observed that considerable transfer occurs already during the formation of a droplet. Observations with sensitive Schlieren methods showed that droplets generally do not emit matter into the surrounding phase by a diffusion process, but by sudden explosive impulses ("eruptions"). When the droplet absorbs matter from the surrounding phase, too, the processes involved are likewise impulsive. Two physical effects are sufficient to explain all observations made so far: 1) Motion within the interface (tangential motion), and 2) outward or inward deflections of the interface (normal motion).

Liquid-Side Mass Transfer Coefficients in Packed Towers. K. Onda, E. Sada and Y. Murase. *A.I.Ch.E. J. 5,* 235 (1959) June (5 pp.)

Physical absorption of gas by water in a tower packed with Raschig rings has been investigated. The liquid-side mass transfer coefficient which was separated by dividing the capacity coefficient by the wetted surface area is discussed from the standpoints of the two-film and penetration theories. A new and simpler dimensionless group is presented which correlates about 90% of the data reported, including the author's own, within an accuracy of $\pm 20\%$.

Mass Transfer at Low Flow Rates in a Packed Column. V. P. Dorweiler and R. W. Fahien. *A.I.Ch.E. J 5,* 139 (1959) June (6 pp)

Mass transfer in packed columns has been investigated for a variety of column and packing sizes but

at flow rates restricted to fully developed turbulent conditions. Work was undertaken to investigate mass transfer at flow rate conditions in the transition and laminar regions. A dual treatment of experimental data required a knowledge of the variation of concentration and velocity with radial position. A tracer-injection technique was employed which consisted in the introduction of a tracer gas into the center of a bulk gas stream and the measurement of the tracer-gas concentration at various radial positions downstream. The velocity distribution for the packed columa was determined by means of a five-loop, circular, hot-wire anemometer. The test column was a vertical 4-in. pipe, packed with ¼-in. spherical, ceramic catalyst-support pellets.

Methane

Intermolecular Forces and Crystal Properties of Methane. E. Whalley. *Phys. of Fluids 2,* 335 (1959) May-June (2 pp.)

Value of $\Theta_t(CH_4)$ was chosen arbitrarily and the heat capacity of CH_4 up to 15° K was used to determine $\Theta_r(CH_4)$. Heat capacities of CH_3D and CD_4 near the minimum in the heat capacity phase II were then calculated and compared with the experimental values. Best fit was obtaind with $\Theta_t(CH_4) = 82°$ K, $\Theta_r(CH_4) = 158°$ K. Values of $\Theta_t(CH_4) = 85°$, $\Theta_r(CH_4) = 140°$, and $\Theta_t\ (CH_4) = 80°$, $\Theta_r(CH_4) = 160°$, were almost equally good. The experimental heat capacities using $\Theta_t(CH_4) = 82°$ and $\Theta_r = 158°$ are compared with theoretical values. Heat capacity of CH_3D is somewhat too high, but the agreement is probably as good as can be expected when all the limitations of the Debye theory are remembered.

The Kinetics of the Exchange Reaction $CH_3 + CH_4 \rightarrow CH_4 + CH_3$ Using ^{14}C as Tracer. F. S. Dainton, K. J. Ivin and F. Wilkinson. *Trans. Faraday Soc. 55,* 929 (1959) June (8 pp.)

Kinetics of the exchange reaction $CH_3 + {}^{14}CH_4 \rightarrow CH_4 + {}^{14}CH_3$ in the temperature range 200-350° C have been studied by measuring the radioactivity of the ethane formed by combination of methyl radicals. Some experiments are described which indicated that the rate constant for the group displacement reaction $^{14}CH_3 + CH_3COCH_3 \rightarrow CH_3 + {}^{14}CH_3COCH_3$ is only a few per cent of that for the hydrogen abstraction reaction $^{14}CH_3 + CH_3COCH_3 \rightarrow {}^{14}CH_4 + CH_2COCH_3$ at 350° C.

Permeability

Process Natural Gas by Permeation. C. J. Walters. *Petrol. Refiner 38,* 147 (1959) May (4 pp.)

Permeation of a multicomponent mixture through a nonporous film is a process somewhat resembling the common absorption-stripping cycle. Components absorb on one side of the film, diffuse to the other side and revaporize. Certain components go through this process at a faster rate than others. Driving force is pressure difference, the same as is primarily true in absorption and stripping. High pressure on one side of the film corresponds to the high pressure in an absorber and reduced pressure on the opposite side corresponds to the reduced pressure on the stripper. Study shows how effectively light hydrocarbons can be separated through ethylene film. Cell design is comparable to a tube-in-shell heat exchanger.

Phase Equilibria

Are You Sure You Are Usng the Right "K"? S. B. Adler and D. F. Palazzo. Part 1. *Chem. Eng. 66,* 95 (1959) June 29 (6 pp.)

Calculation of liquid-vapor equilibrium constant, *K,* is among the engineering calculations most frequently encountered in the design of chemical process plants and petroleum refineries. If vapor and liquid composition data at equilibrium are available for a particular system, then the constant can be obtained directly. Frequently, however, such data are unavailable. They must be calculated from thermodynamic relationships, or, if available, the data must be checked for thermodynamic consistency and extended to other conditions of temperature, pressure or composition.

Distillation . . . in View of Modern Developments. K. F. Gordon and J. A. Davies. **Part 1A. Phase Equilibria . . . Binary Systems.** *Petrol. Eng. 31,* C-53 (1959) May (4 pp.); **Part 1B. Phase Equilibria . . . Ternary Equilibria.** *Ibid.,* C-46 (1959) June (7 pp.)

In a binary system at a given temperature and pressure, the vapor and liquid compositions are fixed, but not in a ternary. Application of the phase rule will show three degrees of freedom available with only two being used by setting the temperature and pressure. Ternary diagrams are frequently employed to understand better how compositions may vary at constant temperature. There are two ways of representing ternary equilibria, one on triangular coordinates, usually equilateral, and one on rectangular coordinates. Examples of chart construction are shown.

Radioactivity Applications

The Radiolysis of *n*-Pentane and Other Hydrocarbons in the Gas Phase. R. A. Back and N. Miller. *Trans. Faraday Soc. 55,* 911 (1959) June (10 pp.)

Light hydrocarbons from propane to hexane have

been irradiated in the gas phase with the α-particles from solid sources of ^{242}Cm and ^{210}Po, and also with external beams of 250 kV peak X-radiation The relative yields of the products of low molecular weight have been measured and, with the α-irradiations, absolute yields estimated using ionization methods. A study of the initial phases of the reactions was made possible by the use of low-temperature distillation and micromethods of analysis. In this way it has been shown that unsaturated compounds are more important as primary products of irradiation than has hitherto been supposed, and that initial yields of hydogen are much higher than previously reported. Only minor differences have been noted between the products of X- and α-irradiations.

Solubility

Solubility of Liquids in Compressed Hydrogen, Nitrogen and Carbon Dioxide. J. M. Prausnitz and P. R. Benson. *A.I.Ch.E. J 5,* 161 (1959) June (4 pp.)

Vapor-phase solubilities of carbon tetrachloride, *iso*-octane, toluene and *n*-decane were measured in compressed hydrogen, nitrogen and carbon dioxide at 50° and 75° C and at various pressures between 20 and 90 atm. The virial equation of state was used to describe the volumetric properties of the vapor mixtures, and the second virial cross coefficients were evaluated from the solubility data. Results indicate that the vapor phase departs from ideality very quickly for these systems as the pressure increases, particularly at pressures greater than 10 atm.

Thermal Conductivity

Thermal Conductivity Coefficients for Methane and Natural Gas. N. V. Pavlovich. *Gazovaya Prom.,* 45 (1959) No. 5 (5 pp. Russian text.)

As a result of experimental work using the hot wire method, values were obtained for the thermal conductivity of methane and natural gas in the temperature range, −160° — +80° C, and in the pressure range 1-150 kg/cm². Values obtained for methane in kcal/(m)(hr)(°C) were 0.0260, 0.0277, 0.310, 0.360, 0.0460 at 0° C and at pressures of 1, 20, 50, 100 and 150 kg/cm², respectively. Values for typical natural gases also are given.

J. W. Penney

Thermodynamics

Heat of Mixing in the System Nitrogen-Methane. H. Knapp. *Ind. Eng. Chem. 51,* 783 (1959) June (4 pp.)

For extensive studies on the removal of nitrogen from natural gas and the liquefaction of natural gas, accurate data about the behavior of a nitrogen-methane mixture were required. Calculations based on published data show that the heat of mixing is positive and relatively small — 40 Btu/lb mole for a mixture of 50% nitrogen and 50% methane (heat of evaporation for nitrogen is 2800 Btu/lb mole.) Therefore, no appreciable inaccuracy is introduced in process calculations, as far as enthalpy balances are concerned, if heat of mixing is neglected. For consideration of equilibrium conditions, however, the positive heat of mixing has a noticeable effect—a tendency against mixing—which makes the vapor concentrations, especially of the diluted components, higher than expected in ideal mixtures.

Predict Critical Temperature. W. R. Gambill. *Chem. Eng. 66,* 181 (1959) June 15 (4 pp.)

Temperature at which the molecular kinetic energy of translation equals the maximum potential energy of attraction is termed the critical temperature (T_c). This critical property appears in many generalized engineering correlations of other properties. Author outlines best over-all methods as well as useful simpler relations of more limited applicability.

Services Available to GAS ABSTRACTS Readers

Photocopies

Photocopies of all articles abstracted in *Gas Abstracts*, except those enumerated here, are available from the Institute at cost:*

1) Russian Articles.—Abstracts are obtained from services specializing in this field. English translations can be supplied by arrangement with the appropriate abstractor.
2) U.S. Patents.—Printed copies can be secured at 25 cents each (remittance with order) from the Commissioner of Patents, Washington 25, D.C.
3) Books, Special Reports.—When a price is given in the abstract, these should be secured from a bookdealer or the publisher; when stated *free*, from the publisher.

Types of Photocopies

Depending on the "tightness" of the binding (which determines whether pages can be laid flat without breaking the binding), and the color of the paper and ink used in the original being copied, photocopies may take any of several forms:

1. Positive paper prints made by the reflex process.
2. Positive paper prints enlarged by xerography from microfilm negatives.
3. Negative photostats.
4. Positive photostats.

Choice of the method used must necessarily rest with the Institute. All photocopies are approximately the same size as the original material.

Cost of Service

The photocopy service charge is:

First 5 pages or fraction thereof of one article in one issue $1.50

Each subsequent 4 pages or fraction thereof of the above one article in the same issue..... $1.00

Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

Microfilm

Microfilm copies of articles abstracted in *Gas Abstracts* are likewise available at cost.* The material is photographed on 35 mm unperforated negative film at 5¢ per page, with a minimum of 50 pages, $2.50, per order. Invoices are rendered to the Institute's Members and Contributors only; payment in advance is required of others.

The Institute may, at its option, fill orders from non-Members and non-Contributors without payment in advance, but an additional charge of $1.00 to cover billing costs will be made on each such order.

Bibliographies and Literature Searches

The library will prepare bibliographies and make literature searches on a cost basis plus a service charge. A comprehensive statement detailing the problem must be presented with the request.

Gas Abstracts on Cards

The abstracts in each monthly issue are also printed individually on 5 x 8-inch cards. Each card bears at its top the author and subject headings under which it may be filed. As many copies of each card are supplied as there are headings on that card, enabling filing of the abstract under all of its headings, eliminating cross-indexing.

The annual subscription to *Gas Abstracts on Cards*, a mailing of 500-1000 cards each month, is $120.00 to U. S. addresses, $150.00 foreign.

Since the printing order for cards is based on the current number of subscribers, a subscription for this service commences with the month in which the order is received. Back numbers of *Gas Abstracts on Cards* are not available.

Back Numbers of Gas Abstracts

In response to an increasing number of requests from utilities, colleges, and technical libraries which have only recently learned of the reference value of *Gas Abstracts*, the Institute has taken steps to make available single numbers, volumes, or complete files of this publication to date, starting with Vols. 1 (1945) and 2 (1946), some numbers of which are out of print.

The latter numbers are reproduced by a photoprinting process from copies in the Institute's libraries, and Vols. 1 and 2 can now be purchased at $35 per volume, unbound; single monthly numbers are offered at $3 each.

Vols. 3 to date are available at current subscription prices, $18 per volume to U. S. addresses, $22 foreign. Monthly numbers are $2 each.

---

*In requesting and accepting photocopies or microfilm copies, the applicant agrees to the following:

1. The applicant desires this duplication solely for use in lieu of loan or manual transcription. Responsibility for questions of copyright that might arise in this copying, and in the use of the copies, is assumed by the applicant.

2. The applicant understands that the Institute does not sell the photocopies, but merely performs the service of copying at the applicant's request; the fee paid is exclusively for such service and is established on the basis of no profit to the Institute.

3. The Institute reserves the right at its own discretion to decline to make photocopies requested, or to limit the number of copies, within the principle of fair use of copyrighted material.

Publications Abstracted for GAS ABSTRACTS

Air Conditioning, Heating and Ventilating
Air Engineering
Air Pollution Control Association, Journal of
American Chemical Society, Journal of
American Gas Association Monthly
American Gas Journal
American Institute of Chemical Engineers, Journal of
American Petroleum Institute Quarterly
American Society for Testing Materials Bulletin
Analytical Chemistry
Appliance Manufacturer
Applied Chemistry, Journal of
Applied Mechanics, Journal of
Applied Mechanics Review
Applied Physics, Journal of
Applied Spectroscopy
ARS Journal
ASHRAE J.
Australian Journal of *Applied Science*
Australian Journal of *Chemistry*

Basic Engineering, Journal of
Battelle Technical Review
Bituminous Coal Research
Brennstoff-Chemie (German)
British Coal Utilization Research Association Monthly Bulletin and *Quarterly Gazette*
Business Week
Butane-Propane News

California Oil World
Canadian Chemical Processing
Canadian Gas Journal
Canadian Journal of *Chemical Engineering*
Canadian Journal of *Chemistry*
Canadian Journal of *Physics*
Ceramics (British)
Chemical and *Engineering Data,* Journal of
Chemical Society, Proceedings (British)
Chemical and *Engineering News*
Chemical & Process Engineering
Chemical Education, Journal of
Chemical Engineering
Chemical Engineering Progress
Chemical Physics, Journal of
Chemical Processing
Chemical Reviews
Chemical Society, Journal of (British)
Chemical Society, Proceedings (British)
Chemical Week
Chemistry & Industry (British)
Coal-Heat
Coal Utilization
Coke and Gas (British)
College Placement, Journal of
Combustion
Combustion and Flame (British)
Compressed Air
Computers and Automation
Construction Methods and Equipment
Control Engineering
Corrosion
Corrosion Technology (British)
Cost Engineering

Design News
Drilling

Electronics
Engineering for *Industry,* Journal of
Engineering for *Power,* Journal of
Engineers' Digest (British)
Erdöl und Kohle

Faraday Society, Transactions of (British)
Fuel (British)
Fuel Efficiency (British)
Fueloil & Oil Heat

Gas
Gas Age
Gas & Oil Power (British)
Gas Council Research Communications (British)
Gas Heat and Comfort Cooling
Gas Industries
Gas Journal (British)
Gas Times (British)
Gas- und Wasserfach (German)
Gas World (British)
Gazovaya Promyshlennost (Russian)

Heating, Piping & Air Conditioning

Independent Petroleum Association of America *Monthly*
Industrial and *Engineering Chemistry*
Industrial Finishing (British)
Industrial Gas (American)
Industrial Gas (British)
Industrial Heating
Industrial Laboratories
Industrial Research
Industries du Gaz, Journal des (French)
Institute of Fuel, Journal of (British)
Institute of Gas Technology Research Bulletins
Institute of Petroleum, Journal of (British)
Institution of Gas Engineers Bulletins and *Communications* (British)
Instrumentation
Instruments and Control Systems
Izvestiya Akademii Nauk S. S. S. R. Otdelenie Khimicheskikh Nauk (Russian)
Khimiya i Tekhnologiya Topliva i Masel (Russian)

LP-Gas
Lubrication
Lubrication Engineer

Mathematical Tables and Other *Aids* to Computation
Mechanical Engineering

National and *Space Administration Memorandum*
National Fire Protection Association Quarterly
National Gas Bulletin of Australia
National Petroleum News
Nuclear Science and Engineering
Nucleonics

Oil and *Gas* Journal
Optical Society of *America,* Journal of
Organic Chemistry, Journal of

Petroleum (British)
Petroleum Engineering
Petroleum Refiner
Petroleum Technology Journal of
Petroleum Week
Physical Chemistry, Journal of
Physics and Chemistry of Solids (British)
Physics of Fluids (British)
Pipe Line Industry
Pipeline News
Power
Producers Monthly
Product Engineering
Progress (Pakistan)
Public Utilities Fortnightly

Research, Journal of
Research & Engineering; the Magazine of Datamation
Review of Scientific Instruments
Revue Generale du Gaz (Belgian)
Rivista dei Combustibili (Italian)

Science
Scientific Instruments, Journal of (British)
Svenska Gasverksföreningens Månadsblad (Swedish)

Technical News Bulletin

U.S. Bureau of *Mines Bulletins, Information Circulars* and *Reports* of *Investigations*
U.S. Patents
Uspekhi Khemii (Russian)

World Oil
World Petroleum